ECONOMIC INSTRUMENTS FOR ENVIRONMENT SUSTAINABILITY

U.SANKAR & OM PRAKASH MATHUR

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PREFACE

In 1996, the National Institute of Public Finance and Policy (NIPFP: New Delhi) and Madras School of Economics (MSE: Chennai) joined the World Resources Institute (WRI: Washington D.C.), in conducting a cross-country study on Fiscal Instruments for Environmental Sustainability. Sponsored by the World Resources Institute and conducted in three countries namely, India, Mexico, and Poland, the purpose of the study was to probe into the relevance and effectiveness of fiscal mechanisms for addressing the environmental problems. The critical issue for the study was: can economic and fiscal mechanisms effectively address the environmental problems?

The NIPFP and the MSE undertook this study in India, in respect of three sectors i.e., energy, water, and solid wastes which are the principal sources of environmental pollution in Indian cities. As part of the study, the pricing and charging policies and practices in respect of energy, water and solid wastes were examined on the basis of the secondary evidence and published reports. NIPFP conducted studies on water supply and solid wastes; MSE concentrated on the energy sector. The studies were completed in the latter part of 1996 and submitted to the WRI in early 1997. The findings of India studies are being integrated with those of other two countries by the WRI, Washington, D.C.

Considering that the results of these studies may be of wider interest, NIPFP and MSE have decided to put out a summary version. I am happy to release this summary version titled as, *Economic Instruments for Environment Sustainability* for wider audience and dissemination.

We are grateful to the World Resources Institute for sponsoring the study. We are, in particular, grateful to Dr. Theresa Bradely and Dr. Robert Repetto for their very helpful comments on the earlier drafts of the studies.

The studies have been conducted jointly by Om Prakash Mathur (Professor, NIPFP) and U.Sankar (Director, MSE), with assistance from Dr. B.C. Barah on water supply and Dr. G.Mythili on energy. Others who have contributed to the study include R. Anuradha (MSE), Purnamita Dhar, Sandeep Thakur, Sucharita Sen, and Vandana Sipahimalani (NIPFP). I am grateful to them for their painstaking search for the secondary material and analysis of the same for this study. The contribution of Rita Wadhwa in editing the book is appreciated. The camera ready text for printing was ably designed and prepared by S.B. Maan. I would also like to acknowledge the smooth manner in which the partnership arrangement between the NIPFP and MSE functioned on this study.

The views expressed in the publication are solely the responsibility of the authors.

February 1998

Raja J.Chelliah
Chairman

CONTENTS

ACRONYMS

ADB	Asian Development Bank
AMD	Aggregate Maximum Demand
ATF	Aviation Turbine Fuel
BICP	Bureau of Industrial Costs and Prices
bm^3	Billion Cubic Metre
c.i.f.	Cost, Insurance and Freight
CMPDI	Central Mine Planning and Design Institute
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CPCB	Central Pollution Control Board
DWSSD	Delhi Water Supply and Sewerage Board
EHT	Extra High Tension
ESP	Electro Static Precipitator
ETP	Effluent Treatment Plant
FGD	Flue Gas Desulphurization
FO	Fuel Oil
GDP	Gross Domestic Product
HMWSSB	Hyderabad Metro Water Supply and Sewerage Board
hr	Hour
HSD	High Speed Diesel
HT	High Tension
IGCC	Integrated Gasification Combined Cycle
Kcal	Kilo Calories
Kg	Kilogram
Kgoe	Kilogram of Oil Equivalent
kl	Kilolitre
KW	Kilo Watt
kwh	kilowatt hour
lpcd	litres per capita per day
lpd	litres per day
LPG	Liquified Petroleum Gas

LRMSC	Long Run Marginal Social Cost
LSHS	Low Sulphur Heavy Stock
LT	Low Tension
mg	Microgram
MINAS	Minimal National Standards
mm^3	Million Cubic Metre
MoEF	Ministry of Environment and Forests
MT	Million Tonnes
MTC	Million Tonnes of Carbon
mtcr	Million Tonnes of Coal Replacement
mtoe	Million Tonnes of Oil Equivalent
mw	Mega Watt
NCU	National Commission on Urbanisation
Nm^3	Newton meter
NO_x	Nitrous Oxides
NPC	National Productivity Council
ORG	Operations Research Group
PC	Pulverized Coal
PLF	Plant Load Factor
R^2	Coefficient of Multiple Determination
$\bar{R}^2$	Adjusted R^2
ROM	Run of Mine
SEB	State Electricity Board
SMD	Simultaneous Maximum Demand
SO_2	Sulphur Dioxide
SO_x	Sulphur Oxide
SPD	Simultaneous Peak Demand
SPM	Suspended Particulate Matter
T & D	Transmission and Distribution
TERI	Tata Energy Research Institute
TNEB	Tamil Nadu Electricity Board
UHV	Useful Heat Value
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WHO	World Health Organisation
WRI	World Resources Institute
yr	Year

INTRODUCTION

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INTRODUCTION

This study examines the scope of using economic instruments for raising the efficiency of resource use and reducing environmental damages from air, water and solid waste pollution. The main objective of the study is to analyse the efficient pricing and taxation of energy, water and solid waste disposal through (a) pricing of publicly provided resources; (b) taxation of, or user charges for products or effluents; and (c) modification of subsidy structures. Energy resources include coal, petroleum and gas fuels, and electricity in their major forms and uses. Water includes municipal and industrial water supply and water-borne waste disposal. Solid waste disposal is confined to urban areas.

All the three energy resources—coal, petroleum and natural gas, and electricity—are private goods. Until recently coal and petroleum and natural gas had been public monopolies under central government ownership and control. In electricity, there is a mix of private and public utilities, but the share of the private sector in total electricity sold is less than 5 percent. The central sector units are engaged only in power generation. At the state level, the state electricity boards (SEBs) are entrusted with the responsibility of generation or purchase of electricity, and its transmission and distribution. In this sector the analysis is at the macro level.

Water supply and sanitation and solid waste disposal services are provided by municipalities and state level water supply and sewerage boards. Water supply is considered as a merit good and hence equity considerations play an important role in its delivery. Sanitation and solid waste disposal services are local public goods. These services are obligatory functions of local bodies. The study on solid wastes is based on data collected from a few selected municipalities.

The economic instruments considered here are prices, user charges, taxes, and subsidies. One may interpret a per unit tax/subsidy as a deviation between price and long-run marginal cost (Hotelling, 1938). User charge is often fixed as a proportion of average cost or operating (variable) cost. Here the concern is on cost recovery. Since almost all the products and services covered in the study are, at present, provided by public sector agencies, there is a close link between pricing/charging/tax policies and budgetary surpluses and deficits of the governments.

The administered prices of energy resources are based on accounting costs which underestimate the opportunity costs of resources. In coal, petroleum and natural gas, the total revenue covers the total accounting costs but there is considerable cross subsidisation in the provision of petroleum products. In electricity, the SEBs have been incurring huge financial losses. Agricultural and domestic consumers are being cross-subsidised by other consumers of power.

In water supply, except in the case of large industrial users in a few selected cities, water charges are unrelated to the cost of supplying water to different categories of consumers. Most small consumers pay lump sum amounts and the poorer sections of population pay little towards the cost of water. In the provision of sanitation and solid waste services, there are no user charges.

In all these sectors what is observed is a syndrome of inadequate and undependable product supply or service provision, lack of adequate resources for investments in capacity creation, and inefficiency in resource use. At present, no effort is being made to internalise the environmental costs through administered prices or user charges.

The economic reforms introduced since June 1991 have encouraged the entry of the private sector in the energy sector and favoured the application of long-run marginal cost pricing principle in the determination of prices for publicly provided products. The *Policy Statement on Abatement of Pollution* issued by the Ministry of Environment & Forests in February 1992 stresses the need for internalising environmental costs in pricing and endorses the adoption of the "polluter pay principle" wherever feasible. The recent 73rd and 74th Amendments to the Constitution of India have opened up the possibilities for making local bodies in the rural and urban areas "institutions of local self-government". The State Finance Commissions set up in each state in pursuance of the amendment acts are required to decide on, among other things, the issue of financing water supply, sanitation and solid waste disposal services.

Against this background this study examines the scope of using economic instruments in improving efficiency in resource use and reducing environmental damages. In the energy sector, the study investigates the effects of (a) a shift from the existing administered pricing regime to one which is based on long-run marginal social costs; and (b) a carbon emission tax on fossil fuels, on the energy prices, energy demands, public sector revenues and environmental improvements. There is, however, available a sound database on production, consumption, prices, revenues and financial performance. Estimations of long-run marginal social costs of the energy products are based both on actual data and certain norms. The information base is generally weak on the estimates of demand elasticities and emission coefficients. However, an attempt is made to infer the effects under certain assumptions within a partial equilibrium approach.

As for water supply and sanitation services, reliable information is available only on the actual costs incurred on the provision of services, water availability, water consumption by large user categories and the provision of some estimates of sanitation services. Water supply is metered for industrial categories, large users, and sporadically for other users. Water treatment facilities are inadequate in most cities. As there is no user charge system for sanitation and solid waste disposal services, it is difficult to study the users' responses to price signals. This study is thus confined to a discussion of alternative methods of financing the services keeping in view the need for providing services to vulnerable groups of population at subsidised prices.

THE ENERGY SECTOR

U. Sankar

with

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THE ENERGY SECTOR

2.1 Introduction

Until recently all enterprises in coal, petroleum and natural gas have been under central government ownership and control. In the electricity sector only 4.4 percent of the generating capacity was under private ownership. The central enterprises are engaged only in the generation of electricity. The SEBs are entrusted with the responsibility of generation (and purchase of power from central power stations), transmission and distribution of electricity in their respective regions.

Investment and pricing decisions of public enterprises have been under government control. The government has also used statutory public monopoly environment to achieve goals other than efficiency namely, equity and regional development. In the petroleum sector kerosene, diesel and liquified petroleum gas (LPG) for domestic use, and naptha for fertilizer use are cross-subsidised by gasoline, aviation turbine fuel and other products. In the power sector, domestic consumers and farmers are heavily subsidised. Most SEBs have been incurring huge financial losses. In the markets for electricity, kerosene and LPG, excess demands have been persisting for a long time. The government has been relying more on quantity controls in the form of quotas, power cuts, and waiting lists, than on the price mechanism to relieve the shortages. There is a growing concern that energy availability, particularly power availability may act as a binding constraint on India's economic growth. Even though nearly all these industries are publicly owned and their products are administered, the environmental costs of producing and using energy have not been included in the costing and pricing of the energy products.

Since June 1991, the government has announced various economic reforms under the stabilisation and structural adjustment programmes. These reforms have opened up the Indian economy to foreign competition, allowed private entry in areas hitherto reserved for the public sector and favoured market orientation in the management of public enterprises. The policy statements issued by the Ministry of Environment and Forests (MoEF) indicate the government's desire to use economic instruments for energy conservation and pollution prevention and control. Market-based instruments can provide signals to users of energy about the relative scarcity of resources and at the same time generate funds for further investments in these sectors.

The specific objectives of the study are to:

- review the supply and demand conditions, pricing policies, financial performances of the enterprises, and reforms initiated in the energy sector;

- assess the environmental damages in production and use of commercial energy, existing environmental regulations, environmental costs and policies for environmental protection;

- explore the feasibility of designing and implementing economic instruments for sustainable use of energy with focus on price reforms and carbon taxes, and assess their impact on energy consumption and improvement in the environmental quality; and

- recommend institutional, technological and other policies to ensure the successful implementation of the economic instruments.

This study is based primarily on published and unpublished data available from government agencies, public enterprises, research institutions, multilateral agencies such as the World Bank, United Nations Energy Programme (UNEP), World Resources Institute (WRI), Asian Development Bank (ADB) and journal articles. It makes use of available estimates of emission coefficients, input-output norms in energy industries, elasticities of demand and so forth.

Section 2.2 reviews the existing scenario related to production, consumption, pricing, financial performance, and the economic reforms initiated. Section 2.3 deals with environmental damages resulting from production and the use of fossil fuels and assesses the existing environmental regulations. Section 2.4 deals with the design and implementation of two economic instruments (i) efficient pricing, and (ii) carbon emission tax and assesses their impact on the environment.

2.2 Existing scenario and reforms initiated

The compound annual rate of growth in commercial energy consumption during 1953-54 and 1991-92 was 6.3 percent. The faster rate of growth of commercial energy, compared with the total energy growth rate of 3.2 percent, indicates a continuous shift from non-commercial to commercial energy owing to factors such as industrialisation, urbanisation, growth in income and change in tastes.

The commercial energy consumption per capita in 1970 was 113 kilogram of oil equivalent (kgoe) as compared with 1195 kgoe for the world and 7655 kgoe for the U.S.A. The per capita consumption in India amounted to 9.5 percent of the world per capita consumption and 1.15 percent of the per capita consumption in U.S.A. In 1991, the per capita consumption in India was 337 kgoe, while the corresponding figures for the world and U.S.A. were 1343 kgoe and 7681 kgoe respectively. Thus in 1991, the per capita consumption in India was 25 percent of the world average and 4.4 percent of the average for the U.S.A.

The energy intensity of the Indian economy, measured in million tonne (mt) ofoil equivalent (mtoe) per Rs 1 billion in constant prices, had increased from 4.76 in 1970-71 to 6.04 in 1993-94. Using the data for the period 1953-54 to 1993-94 the following multiple regression equation with logarithm of commercial energy in million tonne of coal replacement (mtcr) as the dependent variable (lny) and ln GDP in 1980-81 prices (lnX), ln of relative price of fuel (ln P), and time and (time)^2 as explanatory variables, was estimated by ordinary least squares.

$$\ln y = \underset{(2.7155)}{-4.4344} + \underset{(0.2395)}{0.8430} \ln X - \underset{(-0.0662)}{0.1321} \ln P + \underset{(0.0068)}{0.0424} T - \underset{(.0009)}{.00035} T^2$$

$$R^2 = .9963$$

The output and price elasticities are 0.843 and -0.132 respectively.

Coal

The estimate of coal reserves as on 31 March 1995 was 200 billion tonnes of which 68.6 million tonnes was proved. Coal production in 1994-95 was 254 mt, of which 17 percent was coking coal and 83 percent non-coking coal. The sulphur content of Indian coal varies between 0.3 and 0.8 percent, the average being 0.45 percent. The quality of non-coking coal is specified in terms of useful heat value (UHV):

UHV (Kcal/kg)= 8900 - 138 (% ash + % moisture)

The ash+moisture content of non-coking coal varies between 15 to 40 percent; correspondingly the UHV varies from over 6200 to less than 2000.

Coal consumption during 1993–94 was 253 mt of which coking coal was 12.8 percent. About two-thirds of non-coking coal is used by thermal power plants. The administered prices of coal varied from Rs 1048 for steel grade I to Rs 183 for grade G of non-coking coal. The overall return on capital employed was only 5 percent in 1990–91 but it improved to 11 percent in 1992–93.

The central government amended the *Coal Mines Act 1973* with effect from 9 June 1993 to allow private participation in mining for the purposes of power generation and for industrial uses. The government announced deregulation of prices of coking coal and grades A, B and C of non-coking coal in February 1996.

Petroleum and Natural Gas

As on 1 April, 1994, India's proven and balance recoverable crude oil reserve was 765 mt of which 310 mt came from on-shore fields and 455 mt from offshore fields. The estimate of proven balance recoverable reserves of natural gas on that date was 707 bm^3. In 1994–95 production of crude oil was 32.23 mt and imports 27.350 mt. The demand for petroleum products increased at the rate of 7.6 percent per annum during the Eighth Plan.

The prices of both domestic and imported crude oil are pooled in the crude oil prices equalisation account so that all refineries are supplied crude oil at a uniform price. The pricing mechanism for petroleum products is complex. The prices paid to refineries vary depending on their costs of production and various norms. The retention prices for distributing and marketing agencies are based on certain norms of operation.

At present prices of petroleum products such as gasoline, diesel, kerosene, LPG, Fuel Oil (FD), Low Sulphur Heavy Stock (LSHS), Naptha, Aviation Turbine Fuel etc. are administered. The central government fixes the ex-storage point prices for these products. These products account for about 90 percent of the total volume of petroleum products. For other products such as benzene, lube base oil and lubricants, the oil companies are free to fix the selling prices on market considerations.

There has been a steady increase in the price of petrol, but the price of High Speed Diesel (HSD) has been kept at a very low rate. The selling price of kerosene is being maintained far below the cost of supplying it, presumably to make it affordable to poorer sections of the population. The relatively low price of kerosene, compared with diesel, has also resulted in the adulteration of HSD with kerosene. The relatively low price of diesel compared with petrol has encouraged some automobile owners to retrofit the vehicles with diesel engines. Diesel oil, naptha and kerosene are cross-subsidised by petroleum, ATF and other products.

The petroleum sector contributes to central and state government revenues in the form of cess, royalty and gas. The eight public enterprises earned an overall rate of return of 17 percent on capital employed in 1992-93.

The new policy permits private entry in the exploration of oil and gas, refining and marketing of selected petroleum products. It has permitted a parallel marketing system since February 1993 to market some petroleum products which face persistent excess demands as for example, kerosene, LPG and LSHS. Supply of unleaded petrol was started in the four metropolitan cities from 1 April, 1995. The government is considering a phased dismantling of the administered price mechanism.

Power

Of the 86,868 mw of generating capacity at the end of 1993–94, the share of utilities was 88.3 percent. The shares of hydro, thermal and nuclear power in the total capacity of utilities were 25.7 percent, 71.6 percent and 2.7 percent respectively. Of the total power generated by utilities in 1994–95, 23.5 percent was from hydel, 74.9 percent from thermal and 1.6 percent from nuclear plants. Compared with the international standard of 77 percent plant load factor for thermal power plants, the overall plant factor in India was only 60 percent; the figures for central, SEB and private sector plants were 69.2 percent, 55.00 percent and 65.9 percent respectively. The transmission and distribution loss as a percentage of electricity generated was 21.5 percent in 1993–94, about twice the international norm.

The share of industry in electricity consumption had fallen from 67.6 domestic in 1970–71 to 39.7 percent in 1993–94, but the share of agriculture had increased from 10.2 percent to 29.7 percent and that of domestic consumption from 8.8 percent to 18.1percent. During 1993–94, the peak shortage was 16.5 percent and the energy shortage was 7 percent.

The electricity tariffs of SEBs are administered by their respective state governments. Multipart tariff is ubiquitous in India. Users have to bear the initial costs of connection. The bimonthly tariffs for large users namely, industry, commerce, railway traction consist of demand charge and energy charge. No state has introduced time-of-day pricing. For households and LT industries there is only a combined (demand and energy) charge per kwh. Many states now adopt the inverted pricing formula. For agricultural use, many states charge on the basis of horsepower of pumpsets used for large farmers and provide free electricity to small and marginal farmers. Hence the marginal price per kwh for both classes of farmers is zero.

For 1994–95, the weighted average price was Rs 1.30 per kwh while the average cost of providing power was Rs 1.62, thus leaving a shortfall of Rs 0.32 per kwh of power sold. The average price for agricultural users was only 13 percent of the average cost; for the domestic category, this percentage was 55.

In the power sector, the central sector power generating units have been earning reasonable rates of return on capital as they are involved only in power generation. The financial performances of the SEBs have been dismal. During 1994–95, the gross subsidy on account of sale of electricity to agriculture and domestic categories was estimated at Rs 133.1 billion. Rs 53.1 billion was the surplus generated by sale to other sectors. The estimated rate of return on capital employed was –13.5 percent. The estimated gross subsidy for 1995–96 was Rs 157.6 billion and the rate of return was –14.6 percent.

Since July 1991, the government has announced many reforms relating to the power sector. The reforms focus primarily on private power generation. Restructuring of SEBs has not yet begun. The government has announced programmes for generating more power from existing power plants, conservation of power, and generation of power from non-conventional energy sources.

2.3 Environmental damages and policies

Coal

As the overburden to the coal ratio is 4:1, production of 160 mt through open mining involves an overburden of 632 mt. The suspended particulate matter (SPM) levels in some coal mining areas have increased six times since independence. Coal mining also contributes to emissions of methane gas, CH_4.

Indian non-coking coal contains almost 30 percent to 40 percent of ash which is far higher than in many other countries. Of the total ash, about 20 percent is deposited in the form of bottom ash and the remaining 80 percent in fly ash. For a typical 210 megawatt unit plant, (coal with 30 percent ash) on an average, $2.69x10^5$ tonnes of ash have been generated per year. As a result, the dust concentration in the flue gas in the absence of any control measure would be 37.5 gms/Newton meter (Nm^3).

In India, beneficiation of coking coal has been in practice for the last four decades. While beneficiation of non-coking coal has not taken place. A recent exercise carried out for three coal beneficiation plants planned at the coal mine sites of *Dipka*, *Kalinga* and *Piperwar* gives the cost estimates for reducing the ash content of coal from 40 percent to various levels of ash (Table 2.1).

It may be inferred from Table 2.1 that the marginal beneficiation cost is increasing at an increasing rate beyond the reduction of ash below 30 percent Coal beneficiation not only improves the gross calorific value and hence useful heat value of coal, but it also yields other benefits such as increased boiler efficiency, reduction in auxiliary energy consumption, decrease in maintenance cost and more importantly reduction in transportation cost from the mine site to power plant.

Standards for air pollutants

As coal cleaning for non-coking coal is yet to be undertaken, the stringent emission standards notified by the Central Polllution Control Board (CPCB) necessitate an alternative mechanism to control SPM.

Table 2.1
Cost of Beneficiation of Coal*

(Rs per Million Kcal)

Particulars	**I. Dipka Mine**				
	Ash content	**Ash reduction to**			
	38%	**34%**	**32%**	**30%**	**25%**
1.ROM (Run of mine) cost	74.53				
2.Beneficiated coal cost		95.38	102.84	116.73	151.92
3.Beneficiation cost (2-1)		20.85	28.31	42.20	77.39
4.GCV = Kcal/kg	4166	4397	4585	4773	5244
	II. Kalinga Mine				
	41%				
1.ROM (Run of mine) cost	81.12				
2.Beneficiated coal cost		112.69	116.71	127.96	171.97
3.Beneficiation cost (2-1)		31.57	35.59	46.84	90.85
4.GCV = Kcal/kg	3824	4337	4527	4715	5186
	III. Piperwar Mine				
	42%				
1.ROM (Run of mine) cost	63.92				
2.Beneficiated coal cost		79.89	80.11	80.74	100.56
3.Beneficiation cost (2-1)		15.97	16.19	16.82	36.64
4.GCV = Kcal/kg	3700	4410	4598	4786	5256

* Based on the study conducted by Central Mine Planning and Design Institute.

The standards for SPM are 150 mg/Nm^3 in protected areas and 350 mg/Nm^3 for boilers of a size less than 200 mw and 150 mg/Nm^3 for boilers of size 200 mw and above in other areas. The mechanical dust collectors used in older plants are being replaced by more efficient collectors namely, electrostatic precipitators (ESP). Almost all power plants constructed after the mid seventies in India have installed ESP. If ESP works with an efficiency of 99.6 percent (anything below 99 percent is not desirable) then SPM can be reduced up to 99 percent and the added cost as a percentage of generation cost works out to between 2 percent and 4 percent But this excludes the cost of disposal of ash collected in ESP. As the collection mechanism in its dry state is very expensive, fly ash in India is generally collected in a wet form or as slurry, and a large area is required for ash disposal. It is estimated that during 1995, 200 mt of coal consumption produced 75 mt of ash which requires 17700 hectares of land. This problem can be reduced by utilising large quantities of fly ash in the production of bricks and cement and in road making.

As the sulphur content, on an average, in Indian coal (with the exception of Assam coal) is low, Sulphur Dioxide (SO_2) emission is not a problem in India. However, it can reach significant levels owing to clustering of thermal power plants. A typical 210 mw plant with 0.5 percent of sulphur would produce, on an average, 3584 tonnes per year of SO_2 in the absence of any control measure. This corresponds to an emission level of 1.23 gm/m^3.

SO_2 reduction can be achieved by two different methods:

1. Use of tall stacks to increase atmospheric dispersion.
2. Flue gas desulphurisation.

In India, only the first method has been in vogue to control SO_2 emission. The standards prescribed by CPCB for SO_2 are 14 x (Sulphur Dioxide emission in kg/hr)$^{0.3}$ metres for boilers of sizes less than 200 mw, 220 metres for sizes between 200 mw and 500 mw, and 275 metres for size 500 mw or more.

Nitrous Oxide(NO_x) is formed from the nitrogen in the fuel (fuel NO_x) and from nitrogen in the combustion air (thermal NO_x). The formation of thermal NO_x is dependent on the combustion temperature and throughput time. By burning the fuel at a lower temperature and shortening the throughput time of the fuel, the formation of NO_x can be suppressed. By modifying the burner design, it is feasible to reduce the emissions by more than 50 percent Low NO_x burners are still in the development stage. The burner price will add about 5 percent to the generation cost.

Carbon monoxide (CO) and gaseous hydrocarbons are emitted by the combustion process owing to the incomplete combustion of coal. Incomplete combustion may result from low air fuel ratio. The quantities of these gases emitted are so low that they can be neglected. Also any modification that reduces CO generally increases NO_x emissions and vice versa.

There are no standards prescribed for CO_2. Mitra (1993) estimated emission of CO_2 from coal using industries for three years from 1986-87 to 1988-89. It may be noted that, of the total emission, power generation accounts for more than 50 percent followed by steel and cement.

Environment friendly coal combustion technologies

At present all the power generated from coal is based on the Pulverised Coal (PC) plant. The thermal efficiency of a PC plant is low and its emission rate is high. An interim report on *Evaluation of Clean Coal Technology* submitted to the CPCB by the Tata Energy Research Institute (TERI) in December 1994 evaluates four Integrated Gasification Combined Cycle (IGCC) technologies for adoption in India. IGCC is based on the principle of conversion of coal to fuel gas which is burnt in gas turbines to generate power. The hot exhaust gas produces steam in a heat recovery steam generator for generation through conventional steam turbines.

The TERI report notes the following special features which distinguish IGCC power plants from PC plants: (a) reduction in the gestation period for power generation, (b) co-production of power and chemicals, (c) cogeneration opportunities, (d) higher plant availability, (e) less cooling water consumption, and (f) lower emission levels of SPM, SO_x, NO_x and CO_2.

A feasibility study of IGCC technology undertaken by the Council of Scientific and Industrial Research (CSIR) and Bechtel under USAID considered four technologies: Shell, Texaco, KRW and the moving bed gasifiers. It compared the performances of IGCC and PC plants based on the following criteria - plant resource requirements, power outputs, heat rates and efficiencies. The capital required per kw net and costs of generation for the four IGCC plants and two PC plants are given in Table 2.2.

The TERI report concludes that IGCC can be an attractive power generation alternative for India in the future. Among the four IGCC technologies, it prefers the KRW gasifier or similar fluidised bed gasification processes. It also cautions that the gasifier has been proven only on a pilot scale. The moving bed gasifier is less efficient and more costly but it is commercially proven and tested for Indian coal. The Eighth- Five- Year- Plan has allotted funds to build IGCC demonstration plants with a view to demonstrate the commercialisation of technology.

Petroleum and natural gas

Crude oil production can lead to surface pollution and air pollution. Surface pollution results from test spills coming out of the oil wells. Air pollution is caused from the flares or from the emissions coming out of the installations. Flares and oil spills from the installations continue to remain a major concern. The percentage of natural gas flared to gas production has come down from 38.3 percent in 1985-86 to 10.3 percent in 1992-93 and there is a plan to bring it down to less than 4 percent.

Table 2.2
Capital Cost and Generation Costs for Different Technologies

Plant	Capital cost per kw net at 1989 prices Rs	Cost per kwh at 1989 prices Rs	
		5500 hr/year	6000 hr/year
IGCC plant			
Shell	36418	1.46	1.35
Texaco	41500	1.70	1.58
KRW	25292	1.04	0.97
Moving bed	26103	1.16	1.08
PC plant			
Without FGD	19084	0.87	0.81
With FGD	23276	1.02	0.96

Source. Results from CSIR and Bechtel (USAID) feasibility study quoted in "Evaluation of Clean Coal Technology", Interim Report submitted to CPCB, by Tata Energy Research Institute, Dec 1994.

Petroleum refining processes can result in the pollution of water, air and soil owing to their effluents and emissions. Effluent Treatment Plants (ETPs) consisting of physical, chemical and biological treatment sections have been set up in oil refineries. Other measures such as in-plant treatment of pollutant rich effluent streams, segregation of oily waste water and storm water, regular monitoring of treated effluent and receiving water body quality, use of recirculating water systems, extensive reuse of treated effluent are being practised for control of water pollution. All the seven refineries are complying with Minimal National Standards (MINAS) standards relating to quantity and quality.

As for solid waste management, oily sludge from tank bottoms and oil separators is treated in melting pits provided at refineries for recoveries of oil prior to its disposal as land-fill within the refinery premises. It appears that the existing facilities for desludging of the crude oil tankers are limited. Similarly the refineries have very limited capability for reusing the treated effluent. The refineries face problems in the disposal of biological sludge which is generated during the process because dumping sludge is not allowed and its use as a biofertilizer has not been fully established.

The environmental problems in drilling oil and gas and in petroleum, except for gas flaring and treatment and disposal of sludges in the refining process are thus under control. Public firms have an incentive to internalise most of these negative externalities as the prices of crude oil and petroleum productions are administered on the basis of their production costs and they have been operating in a monopoly environment. Even for the private refineries which are subject to strict environmental standards, the producers' prices are administered on the basis of their costs, assuring 12 percent rate of return on their networth.

Emissions from vehicles

India probably provides one of the worst scenarios in the world for emission of pollutants from vehicles. During the last five years, there has been a dramatic increase in the number of vehicles in the country. Table 2.3 shows the figures of different categories of vehicles in the years 1985 and 1991 and their expected increases in the year 2001. As can be seen from the table, there has been a marked increase in the number of two-wheelers in the country within a period of five years.

Table 2.3
Population Growth of Three Different Categories of Vehicles in India

(in million)

	1985	1991	2001
Two-wheelers	5.1	14.1	34.6
Cars, jeeps & taxis	1.5	2.9	4.0
Buses & trucks	1.0	1.8	3.5
Total	7.6	18.8	42.1

Source. CPCB (1984)

The effects of vehicular emissions on human health are well-known. Lead present in the gasoline, when inhaled, causes difficulties in blood circulation. Carbon monoxide (CO) is a highly toxic gas and it gets absorbed in the blood and reduces oxygen intake; NO_x and SO_x aggravate breathing problems and cause eye and throat irritation. People living in air-polluted zones get a persistent cough which remains incurable. Many get constant allergy problems. Suspended particulate matter, when inhaled constantly, probably causes cancer.

The contributions of two- and three-wheelers towards CO and HC are very high, whereas diesel vehicles generate a lot of NO_x and CO. The total emissions of the three pollutants have been estimated to be of the order of 3.4 mt per year in the country.

The CPCB made an assessment of vehicular pollution in major cities using the emission factors laid down by the World Health Organisation (WHO). The estimated emission is given in Table 2.4.

Table 2.4
Estimated Vehicular Emission Load (tonnes per day) in Metropolitan Cities, 1994

Name of the city	Parti-culates	Sulphur dioxide	Oxides of Nitrogen	Hydro Carbon	Carbon Mono-oxide	Total
Delhi	10.30	8.96	126.46	249.57	651.01	1046.30
Bombay	5.59	4.03	70.82	108.21	469.92	658.57
Bangalore	2.62	1.76	26.22	78.51	195.36	304.47
Calcutta	3.25	3.65	54.69	43.88	188.24	293.71
Ahmedabad	2.95	2.89	40.00	67.75	179.14	292.73
Pune	2.39	1.28	16.20	73.20	162.24	255.31
Madras	2.34	2.02	28.21	50.46	143.22	226.25
Hyderabad	1.94	1.56	16.84	56.33	126.17	202.84
Jaipur	1.18	1.25	15.29	20.99	51.28	89.99
Kanpur	1.06	1.08	13.37	22.24	48.42	86.17
Lucknow	1.14	0.95	9.68	22.50	49.22	83.49
Nagpur	0.55	0.41	5.10	16.32	34.99	57.37
Grand Total	35.31	29.84	422.88	809.96	2299.21	3597.20

Source. PARIVESH newsletter CPCB, 2 (1), June 1995

2.4 Economic instruments for environmental protection

The design and implementation of economic instruments which integrate economic and environmental aspects into decision-making in the energy sector are considered here. Efficient social pricing of energy in the Indian context can remove the existing distortions in the energy markets and provide signals to the users of energy about the relative social scarcities of different types of energy. A carbon emission tax based on the carbon emission factor for each fuel which can result not only in energy conservation but also improvement in environment quality must also be considered. Given the fiscal crunch the government is facing and the poor financial status of coal and power enterprises, a judicious application of the instruments can generate adequate revenues for further investments in the sectors.

Price reforms

Electricity prices

An attempt is made to estimate the long-run marginal social costs (LRMSCs) of electricity at the consumer end and to use them for designing electricity tariffs. This exercise adopts the methodology developed by Munasinghe (1979), Sankar (1992) and Sankar and Hema (1985, 1992). The data available from the TERI report on IGCC technology are used. For transmission and distribution (T & D) costs and operation (O & M) and maintenance costs of power plants, the data from the Tamil Nadu Electricity Board (TNEB) is relied upon. Being a normative costing exercise the accounting cost estimates are modified to allow for feasible cost savings owing to improvements in operational efficiency. The cost estimates are at 1994–95 prices.

The capital cost of a KRW plant is taken as Rs 40 million per mw. Assuming a commissioning period of four years, the expected life of the plant as thirty years and a cost of capital at 15 percent the annual cost of capital per KW per year is Rs 7605. Adding operation and maintenance costs of Rs 655 per KW per annum, the annual capital related cost per KW becomes Rs 8260.

For every 1 mw of generating capacity, the desired level of investment in T & D is estimated at Rs 30 million. Assuming a commissioning period of two years, the expected life of the equipment of twenty five years and a cost of capital at 0.15, the capital cost per KW per year is Rs 4989. This cost is distributed among Extra High Tension (EHT), High Tension (HT) and Low Tension (LT) in the ratios 2:1:7. Adding operating and maintenance cost at each voltage level, the capital related T & D costs per KW per annum are Rs 1133 at EHT end, Rs 648 at HT end and Rs 4542 at LT end.

Assuming a reduction in T & D loss from 22 percent to 17 percent, the percentages of peak capacities to generating capacity at EHT, HT and LT ends as 90, 76.5 and 40.9 respectively, and the cumulative loss factors at EHT, HT and LT ends as 1.0702, 1.1962 and 1.3960 respectively, the capacity related costs per KW per year are Rs 10187 at EHT level, Rs 12333 at HT level and Rs 27352 at LT level.

Capital costs at consumer ends

For obtaining the capital costs from the voltage ends to different consumer categories, three additional parameters are required. Following the World Bank studies undertaken for SEBs in India and our earlier work, information on the three parameters for seven categories of consumers is provided in Table 2.5. The monthly capital cost per KW for each category is given in the last column of the table. These figures are obtained by first multiplying

(SPD/SMD) and (SMD/AMD) ratios by the relevant voltage-end costs and then dividing the resulting figures by 12.

As reported in Section 2.3, the cost of coal washing (reducing ash content up to 30 percent) as Rs 0.13 kwh is assumed. The cost per tonne of coal is assumed to be Rs 600 at the pit head and Rs1200 for a plant situated 1000 km from the fuel source. The computation leading to social cost per kwh in given is Table 2.5.

Table 2.5
Customer Category Characteristics and Capital Cost per KW for Consumer Categories

Category	SPD/SMD	SMD/AMD	Load factor	Capital cost per KW per month* Rs
EHT continuous process industries	.85	.90	.75	649
HT other industries	.80	.80	.60	658
HT others	.80	.75	.50	617
LT industry	.60	.80	.30	1094
LT agriculture	.80	.75	.30	1368
LT domestic	.80	.55	.30	1003
LT commercial	.80	.75	.40	1368

* 1 month = 730.5 hours
SPD/SMD = System peak demand by simultaneous maximum demand
SMD/AMD = Simultaneous maximum demand by aggregate maximum demand

The costs given under Case (b) are appropriate only when a power plant is near a coal mine; otherwise one has to take into account the cost of transporting power or coal. In India power transmission cost from pit head station ranges from Rs 0.12 per kwh for short hauls to Rs 0.90 for long hauls. Hence the estimates given under Case (a) of items B and C of Table 2.6 are used as a basis for inferences regarding subsidies and cross subsidies and for price reforms. These unit costs range from Rs 2.30 for HT continuous process industries to Rs 7.62 for LT agriculture.

Table 2.6 A
Social Cost of Energy: Energy Cost at the Generating End per kwh (Rs)

	Case (a)	Case (b)
Coal cost per tonne	1200	600
(a) Coal consumption at 0.72 kg/kwh	0.8640	0.4320
(b) Cost of cleaning coal	0.1300	0.1300
(c) Oil at 1.25 ml/ kwh at Rs 7 per litre	0.0088	0.0088
Total	1.0028	0.5708
Auxiliary consumption (5.5%)	of power generated	
Cost of energy per kwh	1.0612 under case (a)	
	0.6040 under case (b)	

Table 2.6 B
Social Cost of Energy: Energy Cost at Voltage End (Rs)

a. Cost of power at the generating end Rs 1.0612	b. Cost of power at Rs 0.6040
Cost at EHT end	
1.0612 x 1.046 = 1.1100	0.6040 x 1.046 = 0.6318
Cost at HT end	
1.0612 x 1.134 = 1.2034	0.6040 x 1.134 = 0.6849
Cost at LT end	
1.0612 x 1.297 = 1.3763	0.6040 x 1.297 = 0.7834

Table 2.6 C
Social Cost of Energy: Capital and Energy Costs per kwh for Consumer Categories (Rs)

Consumer Category	Capital cost per kwh	Social cost of energy per kwh		Total social cost per kwh	
		(a)	(b)	(a)	(b)
EHT continuous process industries	1.19	1.11	0.63	2.30	1.82
HT other industries	1.50	1.20	0.68	2.70	2.18
HT others	1.69	1.20	0.68	2.89	2.37
LT industry	4.99	1.38	0.78	6.37	5.77
LT agriculture	6.24	1.38	0.78	7.62	7.02
LT domestic	4.58	1.38	0.78	5.96	5.36
LT commercial	4.68	1.38	0.78	6.06	5.46

Table 2.7 gives ratios of the existing tariffs to LRMSC tariffs. All the ratios are less than 1. Estimates of subsidies, based on the differences between the LRMSCs and the existing prices are Rs 568 billion for agriculture, Rs 238 billion for domestic. Rs 187 billion for LT industry, Rs 62 billion for LT commercial and Rs 38 billion for HT industry.

Table 2.7
Electricity Sector: Economic and Market Prices for 1994–95

Consumer category (1)	Average tariff in India/kwh (Rs) (2)	Social cost per kwh (LRMSC) (Rs) (3)	Ratio (4) = (2) ÷ (3)
EHT continuous process industries	2.02	2.30	0.87
HT other industries	2.02	2.70	0.75
HT others	2.40	2.89	0.83
LT industry	2.40	6.37	0.38
LT agriculture	0.22	7.62	0.03
LT domestic	0.88	5.96	0.15
LT commercial	1.91	6.06	0.32

In view of the steep increase in the electricity prices, particularly for LT-end customers, the immediate switch to LRMSC based prices at consumer ends would be politically infeasible. What must also be taken into account are the inflationary implications of steep increase in the price of an intermediate good like electricity.

With private entry in power generation and greater reliance on captive power plants by large industrial and other users, there is a limit to the cross subsidisation of domestic and agricultural consumers by the large users. In a market driven situation, if the cost of getting power from a SEB exceeds the stand alone cost of power for a larger user, the latter has an exit option. The exit of large consumers is not desirable to a utility system.

Equity considerations are important, at the present stage of development, in the pricing of electricity to households in India. As per the 1991 census only 31.1 percent of rural households and 75.9 percent of urban households or 43.0 percent of all households have electricity connections. Also more than one-fifth of the population lives below the poverty line. Hence there is a need for subsidising electricity to small income households upto a prescribed level of consumption. The minimum price for electricity may be set equal to the short run marginal social cost of electricity. This would mean that the electricity price for households with consumption of 100 kwh or less should be increased from the present level of Rs 0.65/Rs 0.75 to Rs 1.38. The unit charge may be raised to cover 50 percent of LRMSC from 1999-2000. For other households, the unit charge may be raised to cover 50 percent of the cost immediately and 100 percent of the cost from 2001-2002.

An immediate increase is called for in the price of electricity for agricultural use. The average price per kwh for this category for the country as a whole is only Rs 0.217, which is far below the price of Rs 0.50 per kwh recommended at the meeting of the state power ministers in 1994. Every effort should be made to raise the price of electricity to cover at least the short-run marginal social cost within a year. As ground water is becoming an increasingly scarce resource, as the alternative cost of pumping water using diesel-based pumpsets or bullock labour is around Rs 5 per kwh, and as most of the farmers with pumpsets are the relatively better off sections of the rural population, there is a case for increasing the electricity price to cover its LRMSC in a phased manner during the next five years. For small farmers cultivating 2 hectares or less, the price may be raised to Rs 3.81 by 1999-2000 so that it will cover 50 percent of the LRMSC.

Development of small scale industries has been encouraged to achieve the goals of dispersed rural development and employment generation. As the cost of providing electricity at the LT end is about 130 percent higher than the cost at the HT end, a steep increase in the price would discourage the growth of these industries. Hence, the price may be raised immediately to cover half of the cost and raised to Rs 4.25 to cover two-thirds of the cost from 1999-2000. As for the LT commercial group, equity and other considerations are less important. However, to avoid immediate steep increase in the charge, the charge may be fixed at two-thirds of the cost immediately and at 100 percent of the cost from 1999-2000.

The time pattern of proposed tariff revisions is given in Table 2.8. By 2000-2001, the only subsidised categories would be small farmers, the LT industry and small income households.

Impact of proposed tariff revision on electricity demand

In order to forecast the effects of the proposed revision of electricity tariffs on the sectoral demands and aggregate demand for electricity, even within a partial equilibrium framework, estimates are required of the sectoral growth rates of outputs, growth rate of GDP, own-price elasticities of demand and output/income elasticities. In Appendix 1 of the earlier report the studies based on the works of other researchers as well as our own on the energy demand functions have been reviewed. Based on these studies and noting the nature of regulation and excess demand conditions in the markets certain parameter values for own price and output/income elasticities (Table 2.9) have been chosen for the exercise.

Table 2.8 A
Tariff Revisions for 1996-97 (at 1994-95 prices)

(Rs per kwh)

Consumer category	Long run marginal social costs			Tariff in 1996-97		
	Capital cost	Energy cost	Total	Capital cost	Energy cost	Total cost
EHT continuous processing industries	1.19	1.11	2.30	1.19	1.11	2.30
HT other industries	1.50	1.20	2.70	1.50	1.20	2.70
HT others	1.69	1.20	2.89	1.69	1.20	2.89
LT industry	4.99	1.38	6.37			3.19
LT agriculture						
small farmers	6.24	1.38	7.62			1.38
large farmers	6.24	1.38	7.62			3.81
LT domestic						
small consumers	4.58	1.38	5.96			1.38
others	4.58	1.38	5.96			2.98
LT commercial	4.68	1.38	6.06			4.04

The proposed tariffs for the five sectors for the selected years, 1996-97 (last year of Eighth-Five-Year-Plan), 1999-2000 (last year of this century) and 2001-02 (last year of Ninth-Five-Year-Plan) are given in Table 2.10. In analysing the price impact an additional assumption has been made that for any price up to Rs 3.00 per kwh, except in the industrial sector, quantities demanded will remain at the 1994-95 levels.

Table 2.8 B
Tariff Revisions for 1999-2000 and 2001-2002
(at 1994-95 prices) (Rs)

Consumer category	Tariff in 1999-2000			Tariff in 2001-2002
	Capital cost	Energy cost	Total	Total
EHT continuous processing industries	1.19	1.11	2.30	2.30
HT other industries	1.50	1.20	2.70	2.70
HT others	1.69	1.20	2.89	2.89
LT industry	-	-	4.25	4.25
LT agriculture	-	-		
small farmers			3.81	3.81
large farmers			5.08	7.62
LT domestic	-	-		
small consumers			2.98	2.98
others			3.98	5.96
LT commercial	-	-	6.06	6.06

The forecasts of the growth rates of electricity demand for the five sectors, under different assumed values of the elasticities, for the three periods are given in Table 2.11. Even with the tariff revision the aggregate demand for electricity will increase at the rate of 6 percent per annum till 1996-97. This result is due to two factors: the low tariff in 1994-95 and xcess demand in the markets for electricity. With phased increases in the prices of electricity, the rate of growth of aggregate demand for electricity is expected to be at 4.5 percent till the end of the Ninth Plan, if the price elasticity is -0.2. If the price elasticity is -0.3, then the annual rate of growth in demand would be 3.75 percent till the end of the Ninth Plan. If electricity prices are frozen at 1994–95 prices, then its demand will grow at the rate of 6 percent per annum.

Table 2.9
Parameter Values Used in the Simulation Study of Electricity Demand

Sector	Sector growth rate	Own price elasticities	Output/ income elasticities
Domestic	6%	-0.05, -0.2, -0.3	1, 1.5
Industry	9%	-0.15, -0.5	1
Agriculture	2%	0	1
Commercial	7%	-0.2, -0.4	1
All sectors (GDP)	6%	-0.2, -0.3	1

Table 2.10
Proposed Tariff for Each Sector

(Rs per kwh)

Sector	Actual	Proposed tariff		
	1994–95	1996–97	1999–2000	2001–2002
Domestic	0.88	2.98	3.98	5.96
Industry	2.20	2.70	2.70	2.70
Agriculture	0.22	3.81	5.08	7.62
Commercial	1.91	4.04	6.06	6.06
All sectors	1.30	3.19	3.91	5.10

Table 2.11
Impact of the Proposed Price Reforms on Electricity Demand

Sector	Own price elasticity	Growth rate between 1994-95 and 1996-97 (%)	Growth rate between 1994-95 and 1999-2000 (%)	Growth rate between 1994-95 and 2001-2002 (%)
Domestic (a)	-0.05	12.36	32.19	45.43
	-0.20	12.36	27.29	30.63
	-0.30	12.36	24.02	20.76
Domestic (b)	-0.05	18.54	49.10	70.61
	-0.20	18.54	44.20	55.81
	-0.30	18.54	40.93	45.94
Industry	-0.15	15.40	50.45	79.39
	-0.50	7.45	42.50	71.44
Agriculture	0	4.04	10.41	14.87
Commercial	-0.20	7.56	19.86	40.18
	-0.40	0.62	-0.55	19.78
All sectors	(At 1994-95 prices)	12.36	33.82	50.36
	-0.20	12.36	27.76	36.36
	-0.30	12.36	24.72	29.36

Note. It is assumed that income/output elasticities are equal to unity except for domestic sector where (a) refers to unitary income elasticity and (b) refers to an income elasticity of 1.5.

Own price elasticity of demand is assumed to be zero upto the price of Rs 3 per kwh for the domestic and commercial sector and for all sectors.

Coal

Following Bhattacharyya (1995), the economic prices for different grades of coal are estimated for the year 1994-95. The fuel price index is used for this price adjustment. These results are reported in Table 2.12. The table reveals that the economic prices are higher than the pithead prices for grades A and F of non-coking coal and medium coking coal. Based on Bhattacharyya's method, the distribution of subsidy/tax by consumer categories for 1994-95 is estimated. These results are reported in Table 2.13. These results indicate that the average pithead price per tonne is Rs 52 above the average economic price.

Table 2.12
Coal Sector: Economic and Market Prices for 1994-95

(Rs /tonne)

Grade of coal (1)	Pit-head price (2)	Economic price (3)	Ratio (4) = (2)÷(3)
	Non-coking coal		
Grade A	645	666	0.97
Grade B	589	446	1.32
Grade C	516	426	1.21
Grade D	409	368	1.11
Grade E	325	235	1.38
Grade F	260	266	0.98
	Coking coal		
Primary coking coal	906	845	1.07
Medium coking coal	542	585	0.93

Primary coking coal includes coking coal of steel grades I, II and washing grade I. Medium coking coal refers to washing grades II, III and IV.

Table 2.13
Coal Sector: Distribution of Subsidy/tax by Major Consumers for 1994-95

Consumer	Consumption (mt)	Assumed distribution of coal by category (mt)					Subsidy/ tax in billion Rs
		PCC	MCC	S	M	I	
Power utilities	167.00	-	-	27.88	83.66	55.46	9.551
Steel plant & cokeries	34.50	34.50	-	-	-	-	2.104
Railways	2.20	-	0.73	1.47	-	-	0.058
Cement	13.10	4.67	8.43	-	-	-	-0.078
Fertilizer	4.00	4.00	-	-	-	-	0.244
Soft coke	3.00	-	3.00	-	-	-	-0.129
Brick kilns	25.00	-	-	-	-	25.00	1.050

PCC - Primary coking coal; MCC - Medium coking coal; S -Superior non-coking coal; M - Medium non-coking coal; I - Inferior non-coking coal.

For pricing purposes, PCC includes steel grades I, II and washery grade I; MCC includes other washery grades coal; S includes coal grades A and B; M includes coal grades C and D and I includes coal grades E and F. Simple averages of prices for different grades are used as the price of any category. Negative sign in the last column implies market price is less than the economic price.

For the coal sector as a whole, setting coal prices for different grades of coal equal to their respective long-run marginal social costs would not result in any significant increase in revenue. Price reforms will result in price increases for coking coal supplied to steel companies and washed non-coking coal supplied to thermal power plants and other users. In the short run, say two or three years, price increases of the order envisaged above will not lead to reductions in demand for the different types of coal.

Petroleum products

The economic prices reported by Bhattacharyya (1995) for 1991–92 to arrive at the prices for 1994–95 have been adjusted by using the import price index of petroleum products. Table 2.14 gives information relating to the economic prices of petroleum products at Bombay for 1994–95. It provides estimates of subsidies in the prices: 54 percent for kerosene, 24 percent for LPG and 1 percent for fuel oil. The retail price of gasoline is 215 percent higher than its economic price. The total subsidies amount to nearly Rs 36 billion for kerosene and Rs 7 billion for LPG.

Table 2.14
Petroleum Sector: Economic and Market Prices (at Bombay) for 1994–95

Product (1)	Retail prices with tax (Rs) (2)	Economic prices (Rs) (3)	Ratio (4)=(2)÷(3)
Gasoline/litre	19.30	6.13	3.15
HSD/litre	7.80	5.63	1.39
Kerosene/litre	2.60	5.71	0.46
Fuel oil*/litre	5.16	5.20	0.99
LPG**/cylinder	91.90	121.40	0.76

* No retail sale, ex-depot rates, exclusive of sales tax.
** One cylinder = 14.2 kg.

The government announced on 2 July, 1996 the following price revisions on petroleum products with effect from 3 July, 1996.

Product	Percentage increase in price
Kerosene for domestic use	0
Naptha (other than fertiliser use)	10
ATF	10
Petrol (Motor spirit)	25
All other products including kerosene for industrial use and naptha for fertiliser use	30

Table 2.15
Petroleum Sector: Distribution of Subsidy/Tax by Major Consumers for 1994-95

(Billion Rs)

Product	Power generation	Industry	House-hold	Others	Transport	Total
Gasoline	-	-	-	-	77.62	77.62
HSD	0.39	4.86	-	3.37	69.73	78.35
Kerosene	-	-	-35.67	-	-	-35.67
Fuel oil	2.06	14.71	-	1.59	1.25	19.61
LPG	-	-1.32	-5.62	-0.13	-	-7.07

The proposed price increases will reduce the deficit in the oil pool account to Rs 20 billion by the end of 1996-97. However, distortions in the price structure still remain. While the open market price of kerosene is Rs 8.10 per litre, the price in the public distribution system is only Rs 2.55. The large deviation between the diesel price and kerosene results in the adulteration of diesel and diversion of kerosene from domestic use to other uses. The gap between petrol and diesel price has widened. Naptha is sold at Rs 3723 per kl for fertiliser units but the same naptha is sold at a price of Rs 6076 for other uses. The price of furnace oil for fertiliser plants is Rs 2812 per kl but the price is Rs 4535 per kl for other uses.

The steep increases in some petroleum prices have received widespread criticisms from the political parties, the business community and the general public. The government was forced to reduce the increase in the price of diesel from 30 percent to 15 percent. There is ,however, still some pressure to reduce the increase in the price of LPG for domestic use.

What would be the effect of the price revision on the demand for petroleum products? There is no increase in the price of kerosene for domestic use. As its relative price has fallen, the demand for kerosene would increase at a rate faster than the rate of growth of household income (6 percent per annum) but the gasoline market is quantity constrained. Allocations of naptha and fuel oil to fertiliser plants are made by the government.

We analyse market responses only in the case of gasoline (motor spirit), diesel and ATF. The results are given in Table 2.16.

The percentage changes in the quantities demanded in the first year would be 1.39 for gasoline, 4.67 for diesel and 4.55 for ATF.

Table 2.16
Impact of Increase in Petroleum Prices on the Demand for Gasoline, Diesel and ATF

Product	Price increase (%)	Own price elasticity	Output elasticity	Growth rate in output (%)	Annual growth rate 1996-97 to 2001-02 (%)	
					With price revision	Without price revision
Gasoline	25	-0.118	0.628	7	3.99	4.49
Diesel	15	-0.068	0.813	7	5.49	5.65
ATF	10	-0.250	1.000	7	6.38	7.00

Proposal for a tax on carbon emissions

Use of fossil fuels in power generation, manufacturing and transportation have been the most important source of CO_2 emissions in India. Mitra (1992) estimates the CO_2 emissions from fossil fuels at 153 million tonnes in 1989-90. TERI (1994) estimates the emissions for the same year at 166 mt. More than two-thirds of the emissions occur from the use of coal. Even though the per capita CO_2 emission was only 0.2 million tonnes of carbon in India, it is expected that, in view of the growing dependence on non-coking coal for power generation and the anticipated high rate of industrial growth at about 9 percent per annum, the per capita emission rate may double before the end of the century. The effects of introducing carbon emission taxes on coal, crude oil and natural gas must be taken into account.

Coal

The distribution of coal use gradewise by sectors is not available. In India, about 72 percent of the non-coking coal was used for power generation in 1994–95. Almost four-fifths of the coal used in thermal power generation corresponds to coal with ash and moisture contents above 35 percent. The weighted average price of pithead coal including cess and royalty per tonne for the two grades was Rs 318 in 1994–95. The total consumption of coal by thermal power plants in that year was 167 mt. Using an emission factor of 1.46 CO_2 per tonne of coal given in the ADB Report, the total CO_2 emissions from the use of coal in power generation is estimated at 243.82 mt.

With an emission factor of 1.46 tonne of CO_2 per tonne of coal and a $5 tax rate per tonne of CO_2, the tax per tonne of coal becomes Rs 229 which means an increase in the price of coal by 72 percent. In this exercise it is assumed that the entire tax is passed on to the users of coal because the existing administered price scheme is cost based and there is excess demand in the market. The estimated total tax revenue at the 1994–95 level of coal use is Rs 38.243 billion. If the tax were set at $10 per tonne of CO_2, the carbon tax per tonne of coal becomes Rs 458 which would increase the price of coal by 144 percent. The expected tax revenue at the 1994–95 level of coal use would be Rs 76.486 billion.

The delivered price of coal to a thermal power plant, apart from the pithead price includes cess and royalty, freight, handling and other charges. If coal is transported for a distance of 1000 miles, then the landed cost per tonne of coal becomes Rs 1247. In this case the price will increase only by 18 percent when the tax rate is $5 and by 36 percent when the tax rate is $10. The cost of delivered coal to power plants situated away from coal mines will also increase because of the increase in the transportation cost resulting from imposition of tax on fossil fuels used in the transportation sector.

When both coking and non-coking coal are considered, the emission factor of 1.88 tonne of CO_2 per tonne of coal given in the ADB Report has been used. Coal consumption in 1994-95 was 268.5 mt. and hence the estimate of CO_2 emission for the year was 504.78 mt. The average price of coal including royalty and cess for 1994-95 was Rs 487. At the tax rate of $5 per tonne of CO_2, the pithead price of coal would increase by 61 percent. The anticipated revenue from this tax at the 1994-95 level of coal use is Rs 79.25 billion. If the tax rate is $10 per tonne of CO_2 (Rs 314), the average price of pithead coal would increase by 122 percent and the total tax revenue at the 1994-95 level of coal use would be Rs 158.5 billion.

Crude Oil

The total consumption of crude oil in 1994-95 was 56.44 mt. Assuming an emission factor of 2.64 tonnes of CO_2 per tonne of crude oil, the total CO_2 emissions from petroleum products was estimated at 149 mt. in 1994-95. A $5 tax per tonne of CO_2 emission implies a tax of Rs 414.48 per tonne of crude oil. Since the price of crude oil inclusive of cess and royalty was Rs 4071 per tonne, with the introduction of the tax, assuming entire shifting of tax, the price would increase by 10.2 percent. The expected revenue from the tax at 1994-95 level of consumption is Rs 23.393 billion. The price increase for a $10 tax is 20.4 percent. The expected revenue from the tax for 1994-95 would be Rs 46.786 billion.

Natural Gas

The total consumption of natural gas for 1994-95 was 19 bm^3. Using an emission factor of 1.9 per tonne of CO_2 per 1000 m^3 of gas, the estimated CO_2 emission from natural gas for 1994-95 was 36.1 mt. The price of natural gas inclusive of royalty and cess in 1994-95 was Rs 2235 per 1000 m^3. Hence with the imposition of the tax, the price of natural gas would increase by 13.35 percent. The expected tax revenue from the $5 tax is Rs 5.668 billion. The expected price increase for the $10 tax is 26.7 percent and the expected revenue is Rs 11.335 billion.

Table 2.17
Impact of Carbon Emission Tax on Fossil Fuel Prices and Tax Revenues

Fuel	Tax rate per tonne of CO_2	Rate of increase in price (in per cent)	Tax revenue at 1994-95 level of use (in billion Rs)
Coal	\$5 or Rs 157	61.0*	79.250
	\$10 or Rs 314	122.0*	158.500
Petroleum	\$5 or Rs 157	10.2	23.393
	\$10 or Rs 314	20.4	46.786
Natural gas	\$5 or Rs 157	13.35	5.668
	\$10 or Rs 314	26.70	11.335
All fuels	\$5 or Rs 157		108.311
	\$10 or Rs 314		216.621

* Pit-head price of coal. Average rate of increase in the retail prices would be about 30.5 percent and 61 percent.

The impact of introducing a carbon emission tax at the rate of \$5 per tonne of CO_2 or \$10 per tonne of CO_2 on the prices of the fossil fuels and on the expected tax revenues, at the 1994-95 levels of consumption of fossil fuels, is given in Table 2.17. The maximum impact of the tax will be on coal prices. If coal is transported for a distance of 1000 km the landed cost would increase only by about 15 percent. Among the three fuels, coal is a relatively abundant fuel in India. A carbon tax will alter the relative fuel prices in favour of petroleum and natural gas and thereby increase the pressure on imports of crude oil and natural gas. But the tax provides an incentive to improve the coal quality by coal washing and coal beneficiation. The government may introduce the tax at a rate of $5 per tonne of CO_2 and use the revenue to finance programmes such as coal beneficiation, development of environment friendly technologies in the energy sector and to adopt energy conservation measures.

The effects of increase in the prices on the demand for different fossil fuels would depend on the own and cross price elasticities of demand, the output/income elasticities of demand and the extent of excess demands in different markets. In fact, we need a general equilibrium framework incorporating the regulatory features and the market conditions in order to analyse the full impact of the tax on the demands for different fossil fuels.

In our work we make rough estimates of changes in the demand for fossil fuels due to the imposition of a once-and-for all carbon emission tax of $5 per tonne of CO_2 in 1995–96, within a partial equilibrium framework under some strong assumptions.

The assumptions underlying the calculations are given in Table 2.18.

Impact on the environment

Based on the information contained in Table 2.18 and further assuming that the CO_2 emissions from coal use are proportional to the quantity of coal consumed, one finds that from 1994–95 to 2001–02 CO_2 emissions from coal use would increase by 82.8 percent in the absence of the $5/tonne carbon emission tax and by 76.70 percent with the carbon emission tax (Table 2.19). If all coal-based plants are required to use washed coal with an ash content of 30 percent by 2001–02, then the annual rate of CO_2 emissions can be reduced from 8 percent to about 6 percent.

Table 2.18
Effects of a Carbon Emission Tax of $5 per tonne of CO_2 in 1995-96 on Demand for Fossil Fuels

Fuel	Rate of increase in price in 1995-96 (in %)	Own price elasticity	Output elasticity	Annual rate of growth of output (in %)	Rate of increase in fuel demand	
					1994-95 to 1996-97	1994-95 to 2001-02
Coal	30.50*	-0.1	1	9	13.76 (7.32)	- 76.70
		-0.2	1	9	-	(8.13)
Petroleum	10.20	-0.1	1	7	13.47 (6.52)	59.56 (6.90)
		-0.2	1	7	12.45 (6.04)	58.54 (6.80)
Natural gas	13.35	-0.1	1	6	11.03 (5.37)	49.03 (5.87)
		-0.2	1	6	9.69 (4.73)	47.69 (5.73)

Note. Figures in parentheses give the annual rates of growth.
* Average increase in the delivered price.

The potential for reducing CO_2 emissions from coal-based power plants by restructuring electricity tariffs appears to be greater than by introducing the carbon emission tax. Using the results in Table 2.12 and assuming that CO_2 emissions are proportional to the power generated from coal-based power plant, we estimate the rates of increase in CO_2 emissions during the period 1994-95 to 2001-02

(a) under the 1994–95 tariff level and (b) under the proposed tariff. With the proposed price reforms, the rate of increase in CO_2 emission from 1994–95 to 2001–02 is 36 percent if the price elasticity of demand is -0.2, and the rate of increase is 29.3 percent over the same period if the price elasticity of demand is -0.3. In the absence of the price reforms, the rate of increase in the emissions would be about 50 percent.

Table 2.19
Effects of a Carbon Emission Tax at the Rate of $5 per Tonne of CO_2 in 1994–95 on the Fossil Fuels on CO_2 Emissions in 2001–02

Fuel	Own price elasticity	Rate of increase from 1994–95 to 2001–02 (%)	
		With the carbon tax	Without the carbon tax
1. Coal	-0.1 till 96–97 and -0.2 thereafter	76.70	82.80
2. Petroleum	-0.1	59.56	60.58
	-0.2	58.54	60.58
3. Natural gas	-0.1	49.03	50.36
	-0.2	47.69	50.36

The volume of flyash produced in 1995 was estimated at 75 mt. Without the carbon tax the volume would increase to 137 mt and with the tax to 132 mt. A tax on flyash generated can serve the coal using plants to internalise the external cost. Alongwith the tax, institutional and technical measures are needed to encourage the use of flyash in the production of bricks and cement and in road making.

Between 1994-95 and 2001-02, reduction in the rate of emissions owing to the imposition of the carbon tax on petroleum and natural gas are relatively small, about 1 percent. As already noted, the impact of price reforms in the petroleum sector on demand is also small. The gain in emission reduction has to come mainly from technical solutions such as improving the quality of engines in new vehicles, installation of catalytic converters, improved quality of gasoline and diesel, and periodical checks of vehicles for their compliance with pollution emission standards.

The above estimations of changes in the emissions are obtained at a highly aggregative level and under very strong assumptions. For example, in the coal based thermal power plants, it is well known that carbon emission factors vary with the size of plant, age of plant and the quality of coal used. In order to compute the aggregate CO_2 emissions from all coal-using plants over time, the distribution of plants by size and vintage along with the gradewise quantity of coal consumed plantwise should be known. However, information is not available.

The impact of the reforms on inter-fuel substitution have not been taken into account because of the lack of reliable estimates for all the sectors and the difficulties in estimating these parameters from the past data. One hunch is that the inter-fuel substitution effects are likely to be negligible in the short run.

URBAN WATER SUPPLY AND SANITATION

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with

Vandana Sipahimalani

Purnamita Dhar

3

URBAN WATER SUPPLY AND SANITATION

3.1 Scope and organisation

The problems of environmental pollution are acute in urban areas. Water scarcity and pollution, emission of hazardous chemicals and automobile and industrial pollution in and around cities are the major sources of urban pollution. Of these, the problems of water pollution are most critical. The huge quantity of waste water and sewage generated by industries as well as by the domestic sector and contamination of ground water from the urban toxic solid waste cause severe water pollution. The hazardous toxic pollutants contaminate the drinking water of shallow tubewells in the slum areas. Shallow hand pumps are a major source and an easy mode of water supply in the slums and squatter settlements. Owing to lack of treatment facilities, a great proportion of untreated waste and sewage flows into open drains. Heavily loaded with pollutants, waste water and sewage enter the water distribution system, especially during the monsoon season, giving rise to many water-borne diseases such as cholera, gastro-enteritis and dysentery. These diseases take a heavy toll of human lives and give rise to severe health hazards. Existing control measures, regulation and fiscal instruments have failed to contain the deteriorating water utility services and pollution abatement in the urban areas.

Against this background, this chapter analyses the factors influencing the demand for and supply of urban water, costs of water supply, prevailing pricing practices and policies relating to sanitation. This chapter is largely based on data collected from four cities—Delhi, Hyderabad, Madras and Bombay. The first three cities have independent undertakings or boards for exclusive management of water supply and sewerage system while the Bombay Municipal Corporation provides water supply services to the residents of the city.

3.2 Water supply

Of the total population of 844.32 million as per the 1991 census, 217.18 million or 25.72 percent lived in urban areas. Between 1981 and 1991 the annual compound rate of growth of urban population was 3.14 percent while the overall growth rate was 2.14 percent. The annual growth rate in the big cities during the decade varied from 5.27 percent in Hyderabad to 2.37 percent in Madras. (Table 3.1.) The share of the slum population in urban population was 24.68 percent.

Table 3.2 provides estimates of statewise population coverage by water supply in urban areas. It shows that while the coverage was 95 percent or above in the metropolitan cities, the figures are rather low in non-metropolitan cities and towns.

Estimates of per capita availability of water and demand for water are given in Table 3.3. The per capita figures for Hyderabad and Madras are even below the norm of 70 litres per capita per day (lpcd) recommended by the WHO for urban areas without a sewerage system. Of the total water distributed, the share of the domestic sector was 87 percent in Delhi for the year 1993-94; the corresponding figures were 63 percent in Bombay and 69 percent in Hyderabad.

Table 3.1
Growth of Population in Urban Agglomerations in India (1981 to 1991)

Urban agglomerations	Population in (millions)		Annual compound growth rate (%)
	1981	1991	
Greater Bombay	8.24	12.60	4.33
Delhi	5.73	8.42	3.92
Madras	4.29	5.42	2.37
Hyderabad	2.55	4.25	5.27
All India urban population	159.46	217.18	3.14
All India population	683.33	844.32	2.14

Source. Census of India (1991).

There is a wide variation in per capita water consumption across consumer groups classified by income even in Delhi which has the highest average per capita availability of water. A communication from Delhi Water Supply and Sewerage Board (DWSSB) in 1995 states that the per capita water consumption in 1992-93 varied from 313 lpcd by the affluent consumers to 140 lpcd by the urban poor and to a mere 16 lpcd by the slum dwellers (Table 3.4).

Table 3.2
State Wise Population Coverage by Water Supply

Name of state/city	Estimated urban population (million) 1991	Population coverage water supply 1988	
		Number (million)	%
Andhra Pradesh (excl. Hyderabad)	13.430	8.400	62.54
Hyderabad	2.670	2.670	100.00
Maharashtra (excl. Bombay)	28.046	27.968	99.72
Bombay	10.500	9.975	95.00
Tamil Nadu (excl. Madras)	18.381	7.456	40.56
Madras	4.352	4.162	95.63
Delhi	8.081	7.965	98.56
All India Total	221.315	185.474	83.80

Note. Coverage figures denote the piped connections only.
Source. Central Pollution Control Board (1988); Ramasubhan, 1988.

Table 3.3
Per Capita Availability of Water and Demand for Water in the Metropolitan Cities

	Per capita availability of water* (lpcd)	Water demand* (lpcd)
Bombay	137	180
Delhi	237	363
Hyderabad	65	120
Madras	47	200

* Availability of water is defined as the total supply of water per person. This supply includes transmission loss of water. The demand for water is estimated by the water authorities based on biological needs, local conditions and the consumption habit of various consumer groups. For example, the estimates take into account the approximate individual requirements of the domestic consumers, industrial and commercial requirements @ 45000 litres per day per hectare in Delhi, 28 percent of total demand in Bombay etc., (fire protection @ 1 percent of total demand), garden use (@ 67000 litres per hectare), requirement for floating population, special use like embassies and hotels and free hydrant supply to the slums.

Source. Individual Water Boards and Municipalities.

Many cities and towns provide water supply for one or two hours per day during normal periods and only one or two hours twice a week during lean periods. The intermittent supply and insufficient pressures keep the pipelines in many areas empty for larger durations. As a result, many high income households, industrial and business users either invest in developing their own water sources or buy water from private sources. Low income households and slum dwellers are the worst affected in periods of water scarcity.

Table 3.4
Average Daily Consumption of Water
by Consumer Category: New Delhi (1992-93)

Consumer group	Water consumption (lpcd)	Monthly household water bill (Rs)	Effective price* (Rs /kl)
Affluent consumers	313	34.14	0.726
Middle income	227	22.18	0.625
Lower income	167	13.90	0.556
Urban poor	140	10.22	0.486
Average			0.633

* Effective price is obtained by dividing the water bill of the household with the actual monthly consumption of water by a typical family of five members. A water bill in Delhi consists of water charges (for various slab rates), an extra charge @ 30 percent on water charge, a pollution surcharge @ two paise per unit of water consumption and an overall 5 percent surcharge.

Source. Personal communication with DWSSB, 1995. A special survey was conducted for this purpose.

3.3 Water costs and tariffs

It is well known that the cost of providing water supply in an urban area depends on factors such as the source of water, cost of transportation of water, pretreatment of water, consumer characteristics and methods of distribution. The cost of water also exhibits spatial and temporal (i.e., season to season in a year) variations. Ideally, measures of current social costs of water to different consumer categories are necessary in order to evolve rational tariffs that would provide correct signals to the users regarding the social scarcity of this resource.

It is very difficult to estimate the social costs of water from the data available with the municipal corporation and water boards. The existing costs are based on historical prices and not at current prices. As the costs are increasing with time, the reported costs underestimate the current incremental costs. No attempt has been made to estimate the social cost of water. Even in an accounting sense, reliable cost data are available only for operation and maintenance costs. Further, as water supply and sanitation services are provided jointly, very often the joint costs are allocated between water supply and sanitation on the basis of some accounting principle.

Estimates reveal that the cost of water per kl is Rs 0.95 in Bombay, Rs 1.70 in Delhi, Rs 5.00 in Hyderabad and Rs 2.94 in Madras. The estimated unit costs for new sources are much higher. For example, the unit cost of water for Madras city from Veeranam tank which is at a distance of 253 km is Rs 14.39 per kl. The unit cost of water for the city of Hyderabad from Nagarjunasagar dam which is situated at a distance of 160 km from Hyderabad is Rs 18.34 per kl.

Slum inhabitants are provided free but inadequate water through public standposts or free hydrants. As many as 40 to 400 families share water from a single hydrant which supplies water up) to a maximum of two hours per day (National Commission on Urbanisation 1988). The per capita water supply is between 15 and 20 litres per day (lpd). In 1992-93, water supply via free public standposts accounted for 14.37 million litres per day (mld) in Hyderabad (3.5 percent of total water supply). Delhi's free distribution of water in 1992–93 was 164 mld or 8 percent of its total water supply.

Consumers who get municipal water supply through pipelines are divided into two broad categories: (i) metered and (ii) non-metered. Non-metered users pay flat rates. In Delhi the monthly charges in 1991–92 consisted of (i) Rs 12.00 up to three taps and Rs 5.00 for each additional tap and (ii) a surcharge of 30 percent. In Hyderabad the fixed monthly charge was Rs 60 per connection in 1991. In Bombay the non-metered charges consist of (i) tax on rateable value (about 9 percent) and (ii) water benefit charge (6 percent of rateable value). In Madras domestic piped water supply is not metered and the flat rate is Rs 30 per month.

The metered charges for different categories of consumers in Delhi and Hyderabad are given in Table 3.5. Two broad features emerge from this table. First, for every category one can observe a multipart inverted tariff which means the average water charge per kilolitre (kl) is higher for large consumers than for small consumers. Second, the water charges are lower for domestic consumers compared with non-domestic consumers. In Bombay the charge per kl is the same irrespective of consumption in each category. The rate is only Rs 0.30 per kl for domestic purposes, but it varies from Rs 2.00 to Rs 6.00 for different categories of industrial and commercial consumers.

Table 3.5
Water Tariffs in Delhi and Hyderabad (metered charges)

	Consumption level	Rs per kl/ minimum
Delhi 1991–92		
Domestic & residential	up to 20 kl per month	0.35
	above 20 kl per month Surcharge 30%	0.75
Non-domestic (shops, offices household industries)	up to 50 kl per month above 50 kl per month surcharge 30%	3.00 5.00
Other non-domestic	up to 50 kl per month	5.00
	50 to 100 kl per month	6.50
Hyderabad		
Domestic	15–25 kl per month	2.50
Multistoreyed buildings	above 25 kl	3.00
(a) 90% or more plinth area in domestic use	up to 500 kl above 500 kl above agreed quantity	2.50 3.00 5.00
(b) 70% - 90% of plinth area in domestic use	up to agreed quantity above agreed quantity	4.00 5.00
(c) more than 30% of plinth area in non-domestic use	up to 20 kl up to 50 kl above 50 kl	100 minimum 5.00 7.00
Industrial	up to 25 kl 25 to 500 kl above 500 kl	200 minimum 7.50 10.00
Commercial	up to 20 kl 20–50 kl above 50 kl	100 minimum 5.00 7.00
Institutional		4.00

3.4 Cost recovery, subsidies and need for reforms

A recent study by Sipahimalani (1995) shows that, among the four cities covered in this study, only in Bombay the average revenue per kl is close to the average cost of water supply. The overall satisfactory financial performance in Bombay is due to heavy cross subsidisation of domestic consumers by non-domestic consumers. Table 3.6 gives details regarding estimates of subsidies for Municipal Corporation of Hyderabad for 1992–93. The non-domestic category's cross-subsidy to the domestic category amounted to Rs 11.284 million per month. As a result the overall subsidy was limited to Rs 6.146 million.

Estimates of subsidies and cross-subsidies given by the boards do not reflect even the current private costs. As noted earlier, the incremental cost of providing water is far above the average accounting cost. As the cost of supplying water varies from one customer category to another, the measurement of unit subsidy as the difference between the average cost for the entire system minus the average revenue for each category becomes questionable.

Underpricing of water perpetuates budget deficits of local bodies. It makes them financially dependent on State governments and other sources for undertaking new projects. The price mechanism is suppressed in relieving growing water shortage as the local bodies often resort to quantity rationing. Irregular and uncertain supply conditions have led many large users to find private sources of water.

Table 3.6
Estimates of Subsidies per month to Various Consumer Categories in Hyderabad (1992–93)

Consumer category	Water supply mld	Tariff Rs /kl	Total cost Rs million	Revenue Rs million	Subsidies Rs million
Free public standpost (#4788 connections)	14.37	Free	2.181	0	2.181
Domestic					
– Unmetered (#5700 connections)	5.70	60/pm	0.864	0.342	0.520
– Metered					
Slab 1 (<15kl/m)	66.38	2.00	5.814	3.988	1.831
Slab 2 (15–25)	71.08	2.50	10.79	5.629	5.161
Slab 3 (>25)	4.937	3.00	7.494	6.370	1.124
Multistoreyed buildings	51.54	3.50	7.824	4.638	3.186
Domestic total	258.44	–	–	–	–
Bulk supply					
– Municipalities	–	2.25	–	–	–
– Enroute villages	–	1.75	–	–	–
– Housing colonies	–	2.25 (up to 300 kl/pm) 3.00 above			–
Total bulk supply	69.64	–	10.572	7.152	3.420
Sub-total	328.08	–	–	–	17.423
Non-domestic	71.23	–	10.813	22.097	(–)11.284
Grand total	399.31	–	–	–	6.146

Source. Hyderabad Water Supply & Sewerage Board (1993).

There is an urgent need for structural and price reforms in the water delivery system. Except for the poor, there is no justification for providing water at zero or very low price. The poor consumers should be targeted and they should be provided at least 40 litres per capita per day (lpcd). For all other consumers water charges should be based on meter readings. The Hyderabad experiment in modernisation and upgradation of water connections with tamper-proof meters deserves recognition. It involves a one time investment of Rs 10,000 per connection and at a 12 per cent rate of interest. This amount can be recovered on the basis of a monthly charge of Rs 52 per connection over a period of 10 years. Installation of a meter and introduction of a charge system where the charge reflects the marginal cost of water can bring not only more revenue to the boards but also conserve water use.

The Bureau of Industrial Costs and Prices has in an analysis shown that technological upgradation and modernisation of Indian industries has promoted conservation of scarce water to a great extent. Water requirement per tonne of area has declined from 14 cubic metres to 6 cubic metres through water conserving technologies. Bhilai steel has demonstrated a saving of upto 83 percent of total water use with appropriate technology upgradation and other means of conservation. In cities such as Madras and Goa, a cut in water supply to large industrial users (e.g. refineries, fertilizer units) has prompted these industries to undertake investments for recycling of water.

Using the data for Hyderabad and Delhi for the years 1989-90 to 1996-97 a demand function for municipal water was estimated with effective price and total household expenditure as explanatory variables. An own price elasticity of -0.21 was obtained. The relatively low value is due to factors such as the absence of any close substitute for water, supply constraints and small observed variations in the prices. At higher prices, excess demands will decrease and demand would become more elastic. Hence setting prices right would not only generate funds for financing investments but also encourage conservation of water.

There is also ample scope for improving efficiency on the supply side. In Bombay, the distribution loss (between the city reservoir and the consumers, including leakages and illegal tapping of water) is estimated at 20 percent. The transmission losses in Madras, Hyderabad and Delhi are much higher owing to the importation of water from distant sources. The revenue loss because of water losses in Delhi in 1993-94 in terms of cash are estimated at Rs 434.37 million.

3.5 Sanitation

Compared with water supply, the sewerage service has a distinctly larger externality and hence the case for government intervention in the management of waste water and sewerage needs adequate emphasis. About 80 percent of the water used enters into the waste water stream. Urban India is, by and large, deficient in infrastructure to provide adequate treatment facilities for huge quantities of waste water and sewage. According to a CPCB report (1988), the percentages of waste water treatment capacity to total waste water generated were 5 in Bombay, 35 in Hyderabad and 50 in Delhi. In the absence of adequate treatment facilities waste water and sewage are disposed of in the creeks or into rivers and the sea directly. As a result, there is a deterioration in the quality of water in natural water bodies.

It is only in Bombay that the expenditure on sewerage and drainage exceeds its income. In Delhi, the income under this category contributed only 36 percent of the expenditure in 1992-93. At present there is no user charge for sewerage and drainage, based on the volume of waste water and concentration of pollutants. In Bombay sewerage tariffs are set at 50 percent of water charge for metered users; for non-metered users a 5 percent tax on rateable value of real property and a sewerage benefit tax at the rate of 4 percent of rateable value of real property are levied. In Hyderabad a sewerage cess at 20 percent of water charges is levied in respect of connections served by the sewerage system.

In the context of the deteriorating urban environmental quality and the need for augmenting the resources of municipal bodies, there is a case for rationalising user charges by linking the charges to the quantity of waste water generated.

SOLID WASTE SERVICES

Om Prakash Mathur

with

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Sucharita Sen

4

SOLID WASTE SERVICES

4.1 Scope and organization

Solid waste is a major source of environmental pollution in Indian cities and towns. It is estimated that anywhere between 30–35 percent of the total waste remains uncollected from the city roads; similarly, the waste disposal services in most cities and towns are archaic and inadequate, and carry high environmental risks. The combined effect of the inefficiencies in collection, and inadequate and unsafe disposal is evident in widespread insanitation, contaminated water and high incidence of chronic respiratory and communicable diseases. Further, there is evidence to suggest that the overall environmental quality in India's cities and towns may be worsening on account of the pressures of growing urbanization and unregulated growth of cities.

Attempts to address solid waste-related environmental problems in India have focused largely on improving waste collection, by enhancing the frequency of waste collection, increasing trucking capacity, and introduction of mechanized cleaning of city garbage. In a few isolated cases, new institutional arrangements with the participation of non-governmental organizations and the private sector, have come into being for solid waste collection and management. The financing aspects of solid waste services have received little or no attention in the country. No systematic use has been made of the economic and fiscal instruments for understanding the impact of the quantum of waste. There exists neither an incentive for waste reduction, nor a penalty for excessive waste generation or its indiscriminate dumping on roads, kerbsides, or even on the designated landfill sites.

This study is designed to gain a better understanding of the cost structure and the pattern of financing solid waste services in Indian cities and towns. It explores the options for redesigning the charging system in a way that it can have an impact on the pattern of household consumption, and consequently, on the quantum and volume of waste. An effective charging system, the study contends, is essential for reducing waste-related environmental pollution.

The study is based on reports on the existing practices of managing and financing solid waste services in Indian cities. In addition, the study has made use of the budgets and annual reports of a few municipal bodies with a view to further understand the financing aspects of solid waste services. As this study will subsequently show, data on these aspects are extremely sparse which has restricted a proper examination of such issues as the cost of land fills, response of households to alternative systems of waste disposal, and the economic factors affecting production of refuse by households. The sparseness of data has vastly limited the scope and purpose of the study, particularly in respect of estimating even the financial costs involved in solid waste collection, transportation and disposal.

4.2 Solid waste in Indian cities

Indian cities currently produce wastes in the aggregate, 100,000–110,000, metric tonnes, or a per capita average of 0.40–0.42 kg a day. These estimates are, at best, approximations in that these are based, as is the practice, on the trucking or hauling capacity of waste generated in different cities and towns. The National Commission on Urbanisation (1988), on the basis of a sample of 40 cities of over 100,000 population found the mean per capita waste/day to be 0.27 kg (SD±0.11), and the same mean for cities in the population range of 50,000 (SD±0.08). Another survey conducted by the Operations Research Group (1989) indicates an average per capita solid waste of 0.35–0.40 kg; however, based on the trade and commercial activities in the surveyed towns and cities, actual per capita waste quantity is estimated by the same study to be higher than shown here (Table 4.1) The study also found significant variations in the amount of waste generated among cities, the low and high being 0.12 kg and 1.26 kg per capita, with the difference being explained by the nature of the economic base of the cities. Given the fact that these capacities are often lower than the quantities of waste generated, and also the fact that rag-picking in India is an actively growing industry, these figures from all cities, would be gross underestimates. The actual waste would be at least 30–40 percent higher than these figures.

Table 4.1
Number of Cities by per capita Waste Generation

Kg per capita	**Number of cities**	
	NCU estimate	**ORG estimate**
< 0.20	9	4
0.20 - 0.30	21	6
0.30 - 0.40	8	11
0.40 - 0.50	7	8
0.50 - 0.75	-	3
0.75 - 1.00	-	2
> 1.00	-	1
Total	45	35

Source. (1) Report of the National Commission on Urbanisation (1988).
(2) Operations Research Group (1989).

4.3 The institutional, regulatory and legal framework

Solid waste collection, treatment and disposal in India are a *statutory* responsibility of municipal governments; the other two levels of governments, namely, the central and state governments, have a limited role in this task. In recent years, however, as a result of the increasing recognition that wastes are a major hazard combined with the fact that wastes have important economic value, the Government of India through the MoEF have constituted a National Waste Management Council. The Council has the following mandate:

- promotion of collection, collation and publication of information regarding the availability of waste technologies, and markets for recoverable materials;
- analysis of information for overcoming constraints to use available technologies for both waste utilisation and waste minimisation and identification of areas in which new technologies need to be developed;
- offering advice to the government, industry and such other sectors on different aspects of waste management and on incentives/disincentives that may be needed to facilitate waste utilisation;
- recommendation to the government research and development schemes for developing new technologies;
- advising government on fiscal and regulatory measures to promote waste utilisation; and
- promoting awareness among the public about different

aspects of solid waste.

It is, however, too early to assess the effectiveness of this newly formed council, and the role that this council will play in this sphere.

The role of the state governments is limited to overseeing the functioning of the municipal governments' mandate to manage solid waste collection and disposal. The state governments are also responsible for financing expenditure of a capital nature, as for example, purchase of equipments, machinery, and trucks. Each state's municipal laws detail out the local governments' obligatory and discretionary functions. The provision of solid waste services is an obligatory function of municipal governments for the simple reason that it is a "public good", it is "non-exclusive", and it is "non-rivalled". This service is non-exclusive, meaning that once it is provided to a city or a community, it benefits the overall public welfare. It is also non-rivalled, meaning that any resident can enjoy the benefit of the service without diminishing the benefit to anyone else. It is not feasible to exclude from service those who do not pay, because public cleanliness and safe disposal of waste water are essential to public health and environmental protection . These laws vary from state to state. The *Gujarat Municipalities Act*, for instance, provides that the municipal councils shall make provision for cleaning of public streets and places. The Madhya Pradesh *Act* vests this responsibility partly on households by requiring them to deposit the refuse and other offensive matter in public dustbins, leaving the municipal governments responsible for collection of waste from dustbins and for transportation and disposal.

The regulatory framework in India for waste collection is dispersed. While environmental standards have been set for water and air quality in specific and general environmental laws, there exists no separate legislation for solid waste management. At present, pollution owing to disposal of solid waste falls within the purview of the 1974 and 1977 *Water Acts*, the 1981 *Air Act*, and the 1986 *Environment Protection Act*. Hazardous wastes are regulated under the "Hazardous Waste (Management and Handling) Rules, 1989", and the manufacture, storage and import of hazardous chemicals rules, which are in different stages of implementation and which make it mandatory for organizations handling hazardous waste to take steps to ensure that all specified wastes are properly handled and disposed of. These rules also regulate the storage of hazardous substances, hazardous accidents control, and pipelines for pumping hazardous substances.

4.4 Contemporary concerns

Much of the attention in India by the central, state and local governments to environmental problems arising from solid waste has focused on the management of the increasing quantities of waste, application of technologies to solid waste disposal and recycling, and introduction of regulatory instruments. A recent study of the Central Pollution Control Board (1995) identified, for instance, the following priority areas for solid waste:

- utilisation of solid waste for resource recovery;
- selection of proper sites for waste disposal on the basis of environmental impact assessment;
- application of appropriate technology for solid waste through (a) proper design of landfills, and (b) incineration of garbage for power generation, wherever feasible;
- greater use of solid waste for anaerobic digestion/biogas generation, composting etc.;
- Use of solid waste for fuel pelletisation;

- Recycling of paper, plastic, glass, battery waste etc.; and
- Provision of facilities for disposal of hospital waste.

However, no attention has so far been placed on "charging"mechanisms for solid waste services, and assessing the possible impact that appropriate charging could have on the pattern of household consumption, the quantum of waste, and consequently on urban environment. Also, no attention has been given to proper identification of the direct and indirect costs involved in solid waste management or to mechanisms for internalising those costs. The solid waste services continue to be financed out of general taxation, mainly out of the receipts from property taxes.

4.5 Costs and charging mechanisms

Solid waste services in India are financed out of the general tax revenues raised by municipal governments. The general tax revenues of municipal governments, it needs to be noted, consist of revenue yields from property taxes, octroi (a tax on the entry of goods) where it is levied, and taxes on advertisements, non-motorised vehicles, animals and selectively on entertainment. In the inter-governmental allocation of tax powers, the more elastic and buoyant taxes are assigned to the central and state governments, leaving with municipal governments taxes that would generally be characterized by low level of elasticity and buoyancy. Thus, the yields therefrom are rarely able to keep pace with the rising citywide expenditure on basic services.

Taxes on land and property are commonly taken by municipal governments as a source of revenue. A distinguishing feature of these taxes is that the base of these taxes which happens to be the rental value, is widely used for other service taxes as well. Thus, it is common to observe in most Indian cities and towns, a conservancy tax, latrine tax, drainage tax, sanitation tax, sewerage tax, and a fire tax, levied in the form of a surcharge on the same base as is used for property taxes. In Bombay, for instance, apart from a general property tax, there is a water tax, water benefit tax, sewerage tax, sewerage benefit tax, education cess, street tax, tree tax, employment guarantee tax and building repair tax, all levied on the rental value of properties. For the households, industry and business, comprehensive property taxes are the main taxes that serve to provide them with essential services.

There exists no specific charge or a fee for solid waste services, implying that there is no relation between waste generated and what the waste generators might pay. This way, the marginal cost of waste generation is taken to be zero. Thus, apart from a general understanding that revenues generated from the general category of taxes on conservancy, drainage, sanitation etc. will be used for the provision of solid waste services, nothing else is known about their financing. Consequently, several critically important financing aspects, such as, the behaviour of households to alternative forms of charging, the effect of the volume or weight-based pricing on the pattern of household consumption, or of tax policies on waste generation and recycling remain grey areas in the Indian context. Other aspects about which little is known relate to the extent of subsidy in the provision of these services and its effect on the overall municipal finances.

4.6 Financing solid waste services

General taxation

As pointed out earlier, there is no direct charging system for solid waste services in Indian cities and towns. These services are charged, or indeed financed, out of general taxation which, in the case of the sample covered under this study, consists of property taxes and octroi taxes where these taxes are levied. Together with property taxes are the other minor municipal taxes such as advertisement taxes and taxes on non-motorised vehicles which have little significance from the standpoint of revenue generation. Where these sources are not able to meet out the expenditure, grants made by the state governments are used.

A number of observations on the cost and financing mechanisms may be made at this stage.

- The cost data on solid waste relate primarily to establishment, repairs and maintenance, materials, and miscellaneous components. Landfill or the dumping site costs are not included in the cost data; nor are the other indirect costs particularly as these relate to depletion costs associated with landfill. Thus, the costs are grossly understated.

- The cost per tonne or on a per capita basis would also be higher if the municipal governments were collecting 80-90 percent of waste, as against the current average of 60-65 percent of the total waste. To this extent, the cost data need to be adjusted.

- The cost data on solid waste services show wide variations between cities, the explanation of which is to be found in a number of factors, such as the methods employed in waste collection, transportation and disposal, the size of the city, and the physical characteristics of cities. The data scarcity has not permitted any analysis of the economies of scale across the services of collection, transportation and disposal.

- The solid waste services in Indian cities and towns are financed out of the general tax revenues. There is no specific charge or fee for the services. Composting as a method of disposal is carried out on a very small scale, notwithstanding the fact that the waste composition is suited for composting. Income from composting is insignificant. Also, in a number of cities, compost is a commodity that is used by the concerned departments of municipal bodies without any accounting on the income side.

- For most cities, the growth rate of the general tax revenues lies far behind the growth rate of expenditure. Property tax which is an important source of tax revenue has shown signs of stagnation and is constrained by large scale exemption of properties from tax purview and rent control acts. The rental values are hardly updated to reflect the market conditions. As a result, revenues from such taxes do not yield enough to meet the cost of such services as solid waste, street lighting, road maintenance and the like.

- On account of the existing practice of financing solid waste services out of the general tax revenue, there is no incentive or disincentive for households, industry and business to change the pattern of their consumption. It carries the strong assumption that the taxes paid by them are adequate for meeting the cost of the services.

4.7 Charging for solid waste

It is necessary to reiterate here that solid waste services in India have traditionally been viewed as "public goods". This view has been accompanied by a somewhat simplistic argument that public goods should be paid for by public funds and also delivered by public agencies. In recent years, however, there has occurred an adjustment to this view, and as pointed out earlier, this sector has been opened up, *albeit* in only a few places, to private sector participation. It recognises the proposition that there are certain aspects of solid waste services that have the characteristics of "private goods". It is this point of departure that is used here as the basis for outlining the financing options for solid waste services. The financing options as outlined here fall under two possible institutional arrangements: (i) where solid waste collection, transportation and disposal will continue to be a "public responsibility", and (ii) where these services may be provided, either in full or in part, by the private sector.

Under the assumption that it remains a public responsibility, three options appear feasible keeping in view the fact that the objectives are to gain environmental sustainability:

(i) To continue with the present system of financing the services, that is, out of the general tax revenues raised by the municipal governments. This option, if persisted, will further diminish the availability of solid waste services in Indian cities and most likely, exacerbate environmental conditions arising from solid waste.

(ii) To continue financing the solid waste services out of the general tax revenues, but introduce some basic reform measures, particularly in property taxation, so as to generate additional resources. Property tax reform is currently an important agenda in several states of the country. In the state of Andhra Pradesh and in Patna city, the basis of determining the rental value of properties has been changed from that of "rents" to "square meter rates differentiated by the locational characteristics of different areas within cities", which has led to a substantial increase in revenue receipts from property taxes. Given the fact that the "rate basis" is simple and transparent, it offers a large potential for revenue generation from property taxes, and consequently for larger availability of funds for solid waste services. Financing solid waste services out of general taxation carries the distinct advantage of being "equitable", in that property tax payments reflect the ability to pay.

(iii) Replace the indirect charging system by a direct charging system, either with a "flat fee" or a fee determined on the basis of volume/weight of waste. Direct charging has the obvious and unique advantage of being a "charge" as distinct from a "tax", and can therefore be used directly for achieving the objective of environmental sustainability. At the same time, charging according to volume/weight is administratively costly, prone to leakages, and difficult to administer. A "flat fee" as a direct charging mechanism is iniquitous, particularly in Indian cities where intracity income disparities are extremely high, and where a large proportion of households—often as large as 30-40 percent—live in slums and squatter settlements.

Under the second assumption which in a sense, questions the efficiency gains of a purely municipal monopoly, the option will be to contract/sub-contract solid waste services or run the services in partnership with them, under different arrangements:

- To permit the private sector to operate and manage the solid waste to the extent that the private sector sets the "charge" and payment mechanism, and bears the attendant costs including those of the landfill and dumping sites.

- To provide subsidies to the private sector in so far as these are necessary for allotting them the dumping sites and making capital investments.

These options have so far not been examined in the Indian context and it is far from clear as to how the municipal governments would deal with issues such as the refusal by households to pay for the solid waste services or to enter into agreements with the private sector. How would the municipal governments regulate the charges and limit price-setting and collusion? These issues constitute a large research agenda in the Indian context.

There is a new dimension in the matter of service financing with the setting up of Finance Commissions in each state of the country. The State Finance Commissions, set up in pursuance of the 73rd and 74th Amendments to the Constitution of India are required to decide on: (i) the taxes, duties, tolls and fees which may be assigned to, or appropriated by, the municipalities; (ii) the distribution between the state and the municipalities of the net proceeds of the taxes, duties, tolls and fees leviable by the state; (iii) the grants-in-aid to the municipalities from the Consolidated Fund of the State; and (iv) other measures that may be needed to improve the financial position of the municipalities. The issue of financing of solid waste services is vitally linked with the work of the State Finance Commissions.

Table 4.2
Solid Waste Cost-Income Data

Key indicators	Bombay	Delhi	Madras	Calcutta	Hyderabad	Bhopal
Population (million)	9.91	7.17	3.85	4.39	2.91	1.06
Solid waste (tonnes/day)	6,000	4,500	3,500	2,600	1,800	1,300
Per capita expenditure on solid waste (Rs)	79.15	85.90	60.60	46.56	37.02	38.17
Per tonne expenditure on solid waste (Rs)	429.77	367.00	185.39	158.07	105.58	222.47
Expenditure on solid waste as a % of total corporation expenditure (%)	13.46	20.16	21.99	-	10.63	24.54
Per capita revenue generation from solid waste (Rs)	2.33	0.78	0.05	1.48	27.45	0.63
Income from solid waste as a % of total corporation income (%)	0.38	0.18	0.02	0.50	-	0.44
Per tonne income from solid waste (Rs)	12.66	3.35	0.16	4.97	78.28	3.70
Expenditure on solid waste as a % of revenue from property taxes (%)	111.41	48.49	60.10	31.29	124.52	238.86

SUMMARY AND RECOMMENDATIONS

5

SUMMARY AND RECOMMENDATIONS

5.1 The energy sector

Until recently enterprises in coal, petroleum and electricity (with a few exceptions) had public statutory monopoly status. This environment enabled the central and state governments to use the public prices to achieve goals other than efficiency as for example, equity and regional development. In the petroleum group, gasoline and aviation turbine fuel were heavily taxed while kerosene, diesel, LPG for household use and naphtha for fertilizer use were heavily subsidised, but the group as a whole reported reasonable returns on the investments. In the power sector, in 1994-95 the average cost of electricity was Rs 1.62 per kwh while the average revenue was Rs 1.30 per kwh; the average revenues per kwh were Rs 0.22 in agriculture, Rs 0.88 in domestic, Rs 1.91 in commercial and Rs 2.02 in industrial categories. The state electricity boards earned a negative rate of return of -13.5 percent on the capital employed. The estimated subsidy for agricultural and domestic categories was Rs 133 billion in 1994-95.

The economic reforms introduced in June 1991 were triggered mainly by the growing deficit of the central government.

Owing to the resource crunch, both central and state governments could not find adequate resources to finance investments in this sector. Hence private entry was allowed. Now the government favours the determination of administered prices of energy products on the basis of long-run marginal costs. With the passage of legislations relating to the protection of the environment, setting up of central and state pollution control boards, prescribing minimal national standards for air and water pollutants and guidelines for handling solid wastes and growing judicial activism, the need for internalising environmental costs in energy policies is obvious.

Against this background, this study explores the design and implementation of (a) prices based on long-run marginal social costs (LRMSC) (b) carbon emission tax and examines the effects of these proposals on energy demand and improvements in the environment.

Price reforms

The estimates of LRMSCs of electricity are based on normative costs of a relatively clean thermal power plant which uses washed coal with ash content of 30 percent.

The capital cost per kwh ranges from Rs 1.19 for EHT category to Rs 6.24 for LT agricultural category, the corresponding variation in energy cost being Rs 1.11 to Rs 1.38. The combined cost per kwh varies from Rs 2.30 per kwh for HT continuous process industries to Rs 7.62 for LT agriculture. An immediate switch to the proposed tariff would generate a surplus at 1994-95 level of consumption of Rs 834 billion per year. The ratios of tariffs in 1994-95 to the LRMSCs range from 0.03 in LT agriculture to 0.87 in continuous processing industries.

An immediate switch to LRMSC based tariff involves very steep increases in prices for households and agriculture and hence it is politically infeasible. Taking into account the equity aspects and the low penetration of electricity in rural areas, phased increases can be recommended till 2001-02, and contain per unit subsidies at the rates of 33.33 percent of the LRMSC for LT industry and 50 percent of the LRMSC for small farmers and small domestic consumers even in 2001-02.

With the phased implementation of the proposed tariffs, the annual rates of growth of electricity consumption can be reduced from 6 percent per annum during 1994-95 and 2001-02 to 4.53 percent if the own price elasticity of demand is -0.20, and to 3.75 percent if the price elasticity of demand is -0.30.

The proposed price reforms for coal and petroleum products are based on the cost, insurance and freight prices of imports of the commodities. In the coal sector, the ratios of pithead prices of coal to the economic prices ranged 0.97 and 1.38. The price reforms will result in price increases for coking coal and washed non-coking coal. For the sector as a whole, setting coal prices equal to their economic costs would not result in any significant increase in revenue.

In the petroleum sector one can observe a wide variation in the ratio of the retail prices to the economic prices with tax in 1994-95. The ratio was only 0.46 for kerosene and 3.15 for gasoline. When subsidy as the difference between the economic cost and the price is measured, the subsidy for kerosene alone is Rs 35.67 billion for 1994-95. The ration price of kerosene has been frozen at Rs 2.55 per litre but its price in the open market is Rs 8.10. The price of the LPG cylinder in the open market is 75 percent higher than the ration price.

Carbon emission tax

A carbon emission tax based on the carbon emission factors for coal, petroleum and natural gas is proposed. Two tax rates of $5 (Rs 157) per tonne of CO_2 and \$10 (Rs 314) per tonne of CO_2 are considered.

With an emission factor of 1.46 tonne, a tax at the rate of Rs 157 per tonne of CO_2 will increase the pithead price of coal by 72 percent. The estimated tax revenue, at the 1994-95 level of consumption, is Rs 38.24 billion. The landed price of coal for a plant located 1000 km away from the coal mine will increase by 18 percent. For both coking and non-coking coal, as a result of the tax, the pithead price of coal will increase by 61 percent. The anticipated revenue from the tax, at 1994-95 level of consumption would be Rs 79.25 billion.

With a tax at the rate of Rs 157 per tonne of CO_2 the average price of crude oil will increase by 10.2 percent and the anticipated tax revenue, at the 1994-95 level of consumption, would be Rs 23.39 billion. With the same tax rate, the price of natural gas will increase by 13.35 percent and the anticipated tax revenue would be Rs 5.668 billion.

With an imposition of carbon emission tax at the rate of Rs 157 per tonne of CO_2 from 1994-95 the rate of increase in CO_2 emissions from coal use during the period 1994-95 to 2001-02 can be reduced from 82.8 percent to 76.7 percent. If all coal based plants are required to use washed coal with an ash content of 30 percent or less, the annual rate of emissions can be reduced from 8 percent to about 6 percent.

The effects of the carbon tax on the emissions from the use of petroleum and natural gas are rather small. Between 1994-95 and 2001-02, the reductions in the rates of emissions during the whole period would be only 1 percent.

Other reforms

There is an urgent need for depoliticising the determination of energy prices. The central government stressed the need for an independent and transparent Tariff Commission to fix the prices as early as in 1991 but it has been created so far. The government must create such a body.

The information system for pricing must change from an accounting cost based cost allocation exercise to the one based on the social costs. The government should provide technical and institutional support for popularising clean technologies, energy conservation, cogeneration, introduction of time-of-day meters for large users of electricity.

With the opening up of the energy sector to private enterprises, there is an urgent need for structural reforms of the public enterprises. They should be given autonomy and be made accountable. If subsidy or cross subsidy for a consumer category is desired in the public interest, then both the private and public enterprises must bear the cost of social obligations.

5.2 Urban water supply

The per capita water availability in 1992-93 varied between 47 litres per capita per day (lpcd) in Madras to 237 lpcd in Delhi. In Delhi, the quantity consumed in 1992-93 varied between 313 lpcd by the affluent consumers to 140 lpcd by the urban poor and to a mere 16 lpcd by the slum dwellers. Many cities and towns provide water supply for one or two hours per day during normal periods and only one or two hours twice a week during lean periods. The intermittent supply and inefficient pressure keep the pipe system in many areas empty for larger duration.

Sipahimalani (1995) provides estimates of cost of water per kl as Rs 0.95 in Bombay, Rs 1.70 in Delhi, Rs 5.00 in Hyderabad and Rs 2.94 in Madras. The estimated unit costs for new sources are around Rs 15 per kl.

Free distribution of water is done through public standposts or hydrants. Consumers who get water through pipelines come under metered and non-metered categories. For metered category, the charge system consists of a fixed charge and a unit charge based on the number of taps. Non-metered charges consist of a tax and water benefit tax, both based on rateable property value.

Sipahimalani (1995) finds that it is only in Bombay that the average revenue per kl is close to the average cost; here domestic consumers are cross-subsidised by other consumers. In Hyderabad, the cross subsidy to the domestic category was Rs 11.28 million per month and the overall subsidy was Rs 6.146 million per month.

There is an urgent need for structural and price reform in the water delivery system. Except for the poor, there is no justification for providing water at zero or very low price. The poor consumers should be targeted and they should be provided at least 40 lpcd of water. For all other consumers water charges should be based on meter readings. The Hyderabad experiment in modernisation and upgradation of water connections with tamper-proof meters deserves recognition. It involves a one time investment of Rs 10,000 per connection and at a 12 per cent rate of interest, this amount can be recovered on the basis of a monthly charge of Rs 52 per connection over a period of 10 years. Installation of a meter and introduction of a charge system where the charge reflects the marginal cost of water can bring not only more revenue to the boards but also help conserve water use.

This study estimates the price elasticity of demand for water at -0.21. The relatively low value is due to factors such as absence of any close substitute for water, supply constraint and small observed variations in the prices. At higher prices, excess demands will decrease and demand would become more elastic. Hence setting prices right would not only generate funds for financing investments but also encourage conservation of water.

There is also ample scope for improving efficiency in the supply side. In Bombay the distribution loss (between the city reservoir and the consumers, including leakages and illegal tapping of water) is estimated at 20 per cent. The transmission losses in Madras, Hyderabad and Delhi are much higher owing to the importation of water from distant sources. The revenue loss owing to water losses in Delhi in 1993-94 is estimated at Rs 434.37 million.

Urban India is, by and large, deficient in infrastructure to provide adequate facilities for huge quantities of waste water and sewage. It is only in Bombay that the expenditure on sewerage and drainage exceeds its income. At present there is no user charge. The sewerage tariffs are fixed as a percentage of water charge for metered users and as a percentage of rateable value of real property for non-metered users.

5.3 Solid waste services

Indian cities currently produce waste in the aggregate of 100,000 to 110,000 tonnes, or a per capita average of 0.40 to 0.42 kg a day.

Solid waste collection, treatment and disposal are a statutory responsibility of municipal governments. While environmental standards have been set for water and air quality in specific and general environmental laws, there exists no separate legislation for solid waste management.

There also exists no specific charge or fee for solid waste services, implying that there is no relation between the waste generated and what the waste generators might pay. Apart from a general understanding that revenues generated from the general category of taxes (on conservancy, drainage, sanitation etc., which are levied as surcharges on taxes on property and land), will be used for the provision of solid waste services, nothing else is known about their financing. Consequently, several critically important financing aspects, namely, the behaviour of households to alternative forms of charging, the effect of the volume or weight-based pricing on the pattern of household consumption, or of tax policies on waste generation and recycling, remain grey areas in this context.

The cost data on solid waste relate primarily to establishment, repairs and maintenance, materials, and miscellaneous components. Landfill or the dumping site costs are not included in the cost data; nor are the other indirect costs particularly as these relate to depletion costs associated with landfill. The cost per tonne would be higher if the municipal governments were collecting 80–90 per cent of waste, as against the current average of 60–65 per cent of the total waste.

Recognising that certain aspects of solid waste services have the characteristics of "private goods", the study outlines the financing options under two possible institutional arrangements: (i) where solid waste collection, transportation and disposal will continue to be a "public responsibility", and (ii) where these services may be provided, either in full or in part, by the private sector.

Under the assumption that it remains a public responsibility, three options are possible keeping in view the fact that the objectives are to gain environmental sustainability.

(i) To continue with the present system of financing the services, that is, out of the general tax revenues raised by the municipal governments. This option, if persisted with, will further diminish the availability of solid waste services in Indian cities and most likely, exacerbate environmental conditions arising from solid waste.

(ii) To continue financing the solid waste services out of the general tax revenues, but introduce some basic reform measures, particularly in property taxation, so as to generate additional resources. One possible reform is to change the basis of determining the rental value of properties from that of "rents" to "square metre rates differentiated by the locational characteristics of different areas within cities". Financing solid waste services out of general taxation carries the distinct advantage of it being "equitable", in that property tax payments reflect the ability to pay.

(iii) To replace the indirect charging system by a direct charging system, either with a "flat fee" or a fee determined on the basis of volume/weight of waste. Direct charging has the obvious and unique advantage of being a "charge" as distinct from a "tax", and can, therefore, be used directly for achieving the objective of environmental sustainability. At the same time, charging according to volume/weight is administratively costly, prone to leakages, and difficult to administer. A "flat fee" as a direct charging mechanism is iniquitous, particularly in Indian cities where intra-city income disparities are extremely high, and where a large proportion of households—often as large as 30–40 per cent live in slums and squatter settlements.

Under the second assumption which in a sense, questions the efficiency gains of a purely municipal monopoly, the option will be to contract/sub-contract solid waste services or run the services in partnership with them, under different arrangements.

- to permit the private sector to operate and manage the solid waste services to the extent that the private sector sets the "charge" and payment mechanism, and bears the attendant costs including those of the landfill and dumping sites.

- to provide subsidies to the private sector in so far as these are necessary for allotting them the dumping sites and making capital investments.

Examination of these options constitute the future research agenda in the Indian context.

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