Sustainable Energy Policies for Clean Air In India

Background Paper Prepared for

The Atlantic Council of USA

By

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Acknowledgements

The author is grateful to Mr. V.Raghuraman, Senior Adviser-Energy, CII for his valuable comments and suggestions. Thanks are also extended to Mr. Rahul Keshtrapaul, Executive Officer, CII and Jyoti Bhatia, Executive, CII. However, the usual caveat applies.

Section I

Energy Scenario in India

Energy is the basic building block for socio-economic development. Future economic growth crucially depends on the long-term availability of energy in increasing quantities from sources that are dependable, safe and environmentally friendly. At present no single source or mix of sources is at hand to meet the specifications.

Although India is rich in coal and abundantly endowed with renewable energy in the form of solar, wind, hydro and bio-energy, its hydrocarbon reserve is really small (0.4 per cent of world's reserve). Current reserve-to-production ratio for coal, oil and natural gas are 235, 23 and 35 years respectively. India, like many other developing countries, is a net importer of energy, 20 per cent of primary energy needs being met through imports mainly in the form of crude oil and natural gas. The rising oil import bill has been the focus of serious concern due to the pressure it placed on scarce foreign exchange resources and also, because it is largely responsible for energy supply shortages. The sub-optimal consumption of commercial energy adversely affects the productive sectors, which in turn hamper economic growth.

The industrial sector in India is a major energy user, accounting for about 52 per cent of commercial energy consumption. Per capita energy consumption in India is only 277 Kg of oil equivalent (Koe) which is just 3.5 per cent of that in the USA, 6.8 per cent of Japan, 37 per cent of Asia and 18.7 per cent of the world average. But, energy intensity, which is energy consumption per unit of GDP, is one of the highest in comparison to other developed and developing countries. For example, it is 3.7 times that of Japan, 1.55 times of the USA, 1.47 times of Asia and 1.5 times of the World average. Thus, there is huge scope for energy conservation in the country.

In the pre-reform period, the commercial energy sector was totally regulated by the government. The economic reform and liberalization, in the post 90s, has gradually welcomed private sector participation in the coal, oil & gas and electricity sectors in India.

Power Sector in India

The Indian power sector is characterized by shortage and supply constraints. Total installed capacity is around 100,000 MW, excluding captive generation. It consists of about 23,000 MW hydro, 70,000 MW thermal (conventional plus Gas Turbine Combustion Cycle (GTCC)), 2200 MW nuclear and the rest non-conventional including wind. Energy generation from thermal power plants has been 386 TWh, forming over 80 per cent of the total annual electricity generation in 1999-2000.

In 1999-2000, energy and peak load shortages were 6.2 per cent and 12.4 per cent respectively. The industrial sector is the highest consumer of electricity (34 per cent) followed by agricultural (33 per cent) and domestic (16 per cent) sector. The share of electricity consumption by the industrial sector has been declining considerably due to higher power tariff and uncertainty in supply. The industrial sector is increasingly becoming dependent on captive power generation. The domestic sector has shown the highest growth rate in electricity consumption in the recent past. On the other hand, electricity consumption in the agricultural sector has been rising at a rate of 7-8 per cent due to the government's policy of supplying heavily subsidized power to farmers and

massive rural electrification. The subsidy for the agriculture and domestic sectors has risen from Rs[1]. 7248 crore in 1991-92 to Rs. 29807 crore[2] in 1998-99. Lower electricity tariffs in the agricultural and domestic sectors encourage consumers to be wasteful in the use of electricity.

Power Sector Reform

In the first four decades after independence, the provision of infrastructure services in India was largely in the public domain. During that period, there was a common belief that only the public sector could serve the government's interests. India's power sector had been operated in a monopolistic environment where decisions were not always taken on a commercial basis. The sector was governed by the Indian Electricity Act (EA), 1910 and Electricity Supply (ES) Act, 1948. The State Electricity Boards (SEBs), which have monopolistic power to generate and distribute electricity in their respective states, were therefore caught in a vicious circle of shortage of resources and poor operational and financial performances. The financial sickness for most of the SEBs is mainly due to the irrational tariff structure. The average revenue generated is less than the average cost of generation in most of the SEBs. Other factors, which adversely affected the operational performance of SEBs, include:

- low plant load factors (PLF) of thermal power plants in some States (the national average has improved significantly over the years. Present value is 67 per cent)
- high transmission and distribution (T & D) losses mainly due to theft of electricity
- political pressures
- over staffing and
- high auxiliary consumption in power plants.

According to the ES Act, SEBs are required to earn a minimum rate of return (ROR) of 3 per cent on their net fixed assets but unfortunately most of the SEBs have negative internal resource generation. The average rate of return was –17.6 per cent in 1997-98, with a loss of 10,000 crore.

The ill health of SEBs has gradually led to a consensus regarding the need for restructuring of this sector. Over the past decade, the government has taken several steps, aimed at reform of the power sector in order to make the SEBs independent profit centers and able to deliver reliable and good quality electricity at affordable prices. Efforts at power sector reform have included:

- Allowing private sector participation in power generation transmission and distribution
- Restructuring and corporatization of SEBs
- Setting up a Central and State Electricity Regulatory Commissions (CERC/SERC).

[1] Rs = rupees
[2] Crore = 10 million

The power sector reforms started in the state of Orissa. As of now almost all the states have taken up reform processes. The present status of reform and restructuring of SEBs is given in Annex I.

Section II

Air Quality in India

One of the key indicators of the quality of life is a clean environment, which can be further disaggregated in terms of water quality, noise and air quality. Unfortunately, air in most Indian cities has become highly polluted and the concentration of certain pollutants exceeds World Health Organization's (WHO) safety limits by large margins.

Urban Air Pollution

Urban air quality in India has been declining over time due to upward trends in power consumption, industrialization and vehicle use. Nationwide, at over 90 per cent of the monitoring stations, the annual mean concentration of Suspended Particulate Matters (SPM) has exceeded WHO's specified limit (*75 micro-gm/m*^{3}). In cities like *Mumbai, Ahmedabad and Nagpur*, the annual average of SPM is at least three times higher than WHO standards and in *Delhi*[1]*, Kolkata and Kanpur*, the annual average SPM values are over five times the standards. However, the annual average concentration of SO_x and NO_x are generally low in terms of WHO specified limits.

Indoor Air Pollution

Parikh & Parikh[2] (1999) estimated that 82 per cent of SO_2, 38 per cent of NO_2, 88 per cent of volatile organic compound (VOC) and 96 per cent of particulate matter emission in India come from the household sector. Women, children and the older generation, who spend most of their time indoors, are badly affected. The major reasons for indoor air pollution are *inefficient burning of inferior* fuels like cowdung, agricultural residue, coal and fuel wood, along with *poor ventilation systems inside the house*. According to a Tata Energy Research Institute (TERI) study, particulate matter concentrations in kitchens due to the burning of bio-fuels are known to be as high as 30 times the WHO standards, while concentrations at the workplace for primary workers can be as high as 12 times the WHO standard, though outdoor concentrations are about 2.5 times the WHO standard in urban and rural areas, and 8 times the standard in slums in India.

Who Pollutes the Air?

Air pollution is the effect of unsustainable economic activities of production and consumption. Burning of fossil and bio-fuels, industrial process and vehicles in the transport sector- all contribute heavily to air pollution.

Nearly 62 per cent of Indian power generation is from coal fired thermal power plants and 70 per cent of the coal produced every year in India has been used for thermal generation. Although, fortunately, most of the Indian coal has a low sulfur content, burning of coal has been the source of serious environmental problems including the emission of CO_2, NO_x, fly-ash etc.

[1] Details of Air Pollution in Delhi is given in Box 1

[2] Ref: Kirit S. Parikh (ed.) India Development Report 1999-2000, Oxford University Press, New Delhi.

It is reported that the transport sector contributed most of the pollution load (27 per cent NO_x, 74 per cent carbon monoxide [CO], 11 per cent volatile organic compound and 100 per cent lead) in urban areas.

Following are the main factors causing vehicular pollution:

1. Many vehicles are in poor condition, creating more particulates and burning fuel inefficiently. Certain types of engines, such as two-stroke engines, are particularly bad, through new options for improving their efficiency may be available soon. Two-stroke engines are inefficient with respect to four-stroke engines and emit hydrocarbons and smoke at a much higher rate.

2. Lower quality fuel is used, leading to the emissions of far greater quantities of pollutants.

3. Motor vehicles are concentrated in a few large cities.

4. There is a lack of public transport and travel demand management.

5. Bad road conditions and poor infrastructure

As of June 30, 2000, the Central Pollution Control Board (CPCB) identified a total of 1551 medium and large industrial units under the seventeen highly polluting industrial sectors. Of these about 77 per cent are predominantly water polluting, 15 per cent predominantly air polluting and the remaining 8 per cent of the industries are potentially both air and water polluting. Out of 1551 units, 1324 have provided the requisite pollution control facilities, 165 units have closed and 62 units are defaulting.

Air pollution causes many health problems, hinders economic productivity, damages material property and causes ecological changes.

Box 1

Air Pollution in Delhi- A Fact File

Air Quality in Delhi

Delhi is arguably the most polluted city of the four metropolises (Kolkata, Chennai & Mumbai the other three). Delhi's air - as sampled at one of Delhi's greenest areas, namely Lodhi Road - is dirtier now than what it was in March 2000. The concentration of very fine particles, finer than 10 micrometers (PM10), has gone up by as much as 50%, as shown in the analysis of the latest results of monitoring air pollution carried by researchers at TERI. TERI scientists compared the quality of air before the Supreme Court's ban on old commercial vehicles came into force from 1st April 2000 with that after the ban. Their results also show that whereas the concentration of fine particles has gone up, that of NOx, a pollutant given off mainly by diesel vehicles, has come down by as much as 40%.

Air quality monitoring at various traffic intersections in Delhi revealed that while SO_2 concentration was within limits at all locations, the concentration of NO_2 exceeded the standard at Connaught Place, Windsor Place and Pusa Road. CO concentration was recorded much higher than the permissible limit at all locations. Concentration of these air pollutants was found to be high between 8-11 AM and 4-9 PM indicating the impact of vehicular density on air quality.

Who Pollutes?

Two factors point to a worsening of the air pollution situation in Delhi over the next decade – the rapid pace of urbanization and even faster pace of motorization. Delhi's urban population, which was 3.65 million in 1970/71, increased to 5.73 million in 1980/81 and 8.47 million in 1990/91 indicating a more than twofold increase in the last two decades while the corresponding figures of the increase in the vehicle population accounts for 0.20 million, 0.56 million, and 1.8 million, respectively, which indicates more than a nine times increase in vehicles in the last two decades.

Recent estimates show that about 3,000 metric tonnes of air pollutants are emitted everyday in Delhi. The major sources of air pollutants being:

1. Emissions from vehicles (67%),
2. Coal based thermal power plants (13%),
3. Industrial units (12%) and
4. Domestic (8%).

In 1991 the air pollutants emitted daily were 1,450 metric tonnes. Thus it can be seen that the emissions have more than doubled in less than 10 years.

Vehicular emissions constitute a very important component of any strategy to control air pollution especially in Delhi, where vehicles are the major contributors to its air. Atmospheric pollutants commonly associated with motor vehicles are nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), lead (Pb), and PM_{10} . It is notable that two thirds of the vehicles in Delhi are two-wheelers, operated on two stroke engines accounting for 70% of hydrocarbon and 50% of carbon monoxide emissions. The Central Pollution Control Board (CPCB) has been monitoring carbon monoxide at the ITO traffic intersections since 1989. The concentrations of carbon monoxide in 1996 show an increase of 92% over the values observed in 1989.

Air Pollution from Thermal Power Plants: There are three coal based thermal power plants in Delhi, at Indraprastha, Rajghat and Badarpur. Electrostatic precipitators have been installed at all the three power plants to control particulate emissions. Sulfur dioxide and oxides of nitrogen are emitted through stacks of specified height to facilitate wider dispersal so that the ground level concentrations of these gaseous pollutants are kept controlled. Stack monitoring is also done on a regular basis.

Policy Framework Needed to Reduce Air Pollution in Delhi – Steps Taken.
A number of mutually reinforcing policies need to be used in urban areas in general, and the city of Delhi in particular, to try and reduce the growing energy demand and emissions, particularly from the transport sector.

1. **White Paper on Delhi Pollution:** The rapid growth of Delhi in recent times has resulted in a significant increase in environmental pollution and the problem is threatening to get out of hand. Hence, effective and co-ordinated measures for controlling pollution need to be put in place without delay. In view of the seriousness of the issue, the Minister of Environment and Forests decided to have a series of interactive meetings with concerned government agencies, NGOs, experts and citizens, with the objective of defining a plan of action to combat the problem. The outcome of these meetings was a *White Paper on Pollution in Delhi with an Action Plan* concurred on 8 August 1997 covering various aspects of pollution control, including vehicular and industrial pollution, solid waste management and noise pollution.

2. **Supreme Court Directives to Promote Energy Efficient and Clean Vehicles:** An associated gain of the recent order by the Supreme Court of India, disallowing registration of all private non-commercial vehicles in the National Capital Region (NCR) failing to conform to Euro II fuel emission norms from 1st April 2000. This would mean that any new four-wheeled petrol-driven passenger vehicle to be registered after 31st

March 2000 in the national capital region (areas in and around the city of Delhi) would have to meet mass emission norms which, for carbon monoxide, are 2 to 3 times more stringent than the current emission norms, depending upon the reference weight of the vehicle. The corresponding tightening of norms for hydrocarbons and nitrogen oxides together would have to be about 3 to 4 times. Similarly, for new four-wheeled diesel passenger vehicles, the new carbon monoxide emission norms would be 1.2 to 2 times more stringent compared to the present levels, and for nitrogen oxides, the new range would be 2 to 2.4 times stricter. Notably, currently there are no mass emission norms for particulate matter. However, from April 2000 onwards, the maximum particulate emissions allowed will range from 0.14 to 0.25 gm/km,

3. **Old and Polluting Vehicles Ordered off the Road:** Recently The Delhi government directed the ban of two-wheelers more than 15 years old and commercial vehicles more than 12 years old. This move is expected to go a long way in checking the city air pollution. According to CPCB chairman Dilip Biswas "…Of the 30 lakh vehicles in Delhi, nearly 20 lakhs are two-wheelers which due to their two-stroke engines are one of the most polluting vehicles on the road today," Also, 20 per cent of the vehicles cause 80 per cent of the pollution, as they are old, over-used and technologically old. In the same vein, the Delhi government has taken the initiative for promoting green fuel (CNG) driven vehicles on the roads of Delhi by directing all the governments departments and autonomous bodies to buy only the CNG run vehicles. However for other private /commercial vehicles to switch to CNG, inadequate infrastructure for the supply of the fuel is the major constraint which needs to be addressed.

4. **Strengthening of Mass Transportation:** The growth in personalized vehicles in the capital is a direct result of absence of efficient public transport resulting in longer travel time, higher fuel consumption, growing air pollution, greater discomfort to road users and degradation of the local and global environment. Thus from the energy-economic and environmental considerations, the use of mass transport is vastly superior compared to the use of personalized ones. *Delhi Metro Rail Project (DMRP), which is a joint venture of the Government of India and the Delhi Government, is a step in the right direction.* Metro, once operational will run on electricity and will not only relieve congestion of road traffic but will also bring down pollution levels as well as the travel time in the Capital by 50 per cent. Along with the ongoing Metro program the government has also started construction of some 17 odd flyovers as a part of its transport management program.

Section III

Energy Policies to Promote Clean Air

Market and regulatory failures result in extensive levels of pollution, causing damage to human health, and natural and productive assets. The prevention and mitigation of these effects at local, regional and global levels calls for the proper set of institutional arrangements and policy implementation instruments for pollution control. The last three decades have witnessed a spate of governmental legislation creating environmental laws to protect common property resources and the interest of the common people. A list of important environment legislation enacted by the Government of India (GOI) is given in the Annex 2 and the details of this legislation can be seen in the web-site http://envfor.nic.in/legis/legis.html

The salient features of the government policies (within the ambit of Air Act, 1981) to promote clean air in various sectors are outlined below:

Industrial Sector

- Closure of polluting industries after due warnings to remedy the situation.
- Shifting of polluting industries to less polluted locations.
- Carrying capacity based development planning.
- Declaration of air pollution control areas by state governments.
- Industrial zoning followed by Industrial Complexing, for pollution prevention and reuse of wastes.
- Detailed monitoring of air pollution from 17 categories of highly polluting industrial units to make them comply with stipulated norms.
- Time bound action plans for control of pollution in identified "Hot Spots".
- Revision of emission norms.
  - Ministry of Environment and Forests (MOEF) on October, 1999 published emission standards for new generator sets (up to 19 kilowatt) run on petrol and kerosene, details of which are given in Annex 3.

Transport Sector

Emissions all over the country from 18 million on-road vehicles in 1989 totaled 26,000 tons per day (TPD) and will increase to 63,000 TPD from 49 million vehicles by the end of 2001. Therefore, emission control initiatives cover:

- Phased switchover from leaded to unleaded petrol beginning in 1995 initially in the metro cities. *Only unleaded petrol is supplied in all retail outlets of the entire country effective 01.02.2000*
- Introduction of Vehicular Pollution Checks of all vehicles on the roads in the metropolitan cities coupled with phasing out of old vehicles and replacement of two-stroke engines.
- Improved engine efficiency coupled with use of catalytic converters in new vehicles. A Supreme Court directive stipulates the adoption of Euro-1 and Euro-II emission norms in a time bound manner.

  - The Ministry of Surface Transport (MoST), vide GSR 399 (E) dated 01.06.1999 has notified rules relating to the registration of non-commercial four-wheeled petrol and diesel driven vehicles in the National Capital Region to confirm India-2000 emission standards akin to Euro-I emission standards effective on and from 01.06.99 as these standards are effective from 01.04.2000 in the entire country for all types of vehicles.

  - In consultation with the Ministry of Environment & Forests (MoEF), the MoST vide GSR 77(E) dated 31.01.2000 has also notified more stringent emission standards known as Bharat Stage-II similar to Euro-II emission standards for registration of Motor cars and Four-wheeler Passenger Vehicles with Gross Vehicle Weight (GVW) equal or less than 3500 Kg, which should confirm to Euro-II emission norms by 01.04.2000 in the National Capital Region.

- Introduction of low-sulfur diesel and low benzene gasoline in a phased manner along with promotion of alternative fuels like Compressed Natural Gas (CNG).

- 0.25% sulfur in diesel is supplied in the entire country since 01.01.2000.

- The Ministry of Surface Transport has also constituted a committee, vide its order dated 19.01.2000, to work out a phased time table, for introduction of fuel with 0.05% sulfur content maximum throughout the country to enable the stipulation of the Bharat-II emission standards for registration of new vehicles throughout the country.

- The Ministry of Petroleum and Natural Gas has a phased programme for the introduction of low sulfur diesel (0.25% & 0.05% sulfur) as per the plans implemented/under implementation as mentioned below.

Table 1: Plans for Supply of 0.05% Sulfur in Diesel in the Country.

Phase	Date	Area of Supply
I.	01.04.2000	At select retail outlets for new private (non-commercial) vehicles confirming to Euro-II norms registered in the National Capital Region.
II.	01.10.2000	Mumbai for all categories of diesel vehicles.
III.	01.04.2001	National Capital Technology and Taj Trapezium for all categories of diesel vehicles.
IV.	01.10.2002	National Capital Region, Chennai and Kolkata for all categories of diesel vehicles.

Tata Energy Research Institute (TERI) has suggested four mutually reinforcing policies, which need to be pursued in urban areas to reduce vehicular pollution and Green House Gas (GHG) emissions. Table 2 gives a mixed set of instruments, which need to be implemented to address these policies:

- reduce urban congestion through *transport management*,
- scrap highly polluting and high usage *vehicles*,
- promote clean *fuel* and engine *technologies*, and
- strengthen *institutional links and regulatory issues*.

Table 2. Taxonomy of Instruments for the Identified Issues and Recommendations

Target Area	Command & Control	Market Based Incentives
Transport Management	Management Measures (bans and restrictions on private vehicle movements, creation of high occupancy vehicle lanes, and timely clearance of road encroachments), Engineering Measures (provision of side tracks and parking space, pedestrian walkways, redesigning intersections, periodic road maintenance, grade separation and setting up of freight and bus terminals, Control Measures (traffic signals synchronization, display diversion maps.), Parking Restraints, Augumenting Public Transport, Land Use Planning with Regulations.	Congestion charges, Parking charges, Taxes
Vehicles	Emission norms, monitoring & evaluation; Fuel efficiency standards, Inspection & Maintenance, Vehicle scrappage programmes, Retrofit programmes.	Vehicle taxation, Parking charges, Area licensing.
Fuels	Fuel quality standards, Setting up more CNG supply outlets.	Fuel pricing, Remove subsidies on kerosene & LPG.
Institutions & Regulations	Roles and responsibilities of each relevant institution, Revisit rules and regulations to plug the loopholes, Strengthen institutional linkages through effective communication, Develop and maintain a credible database (inventorization of vehicles and their attrition, vehicle utilization, speed, emission factors, continous monitoring of air quality in critical areas, audit and safety aspects), Audit pollution checks, Capacity building of local bodies.	Strict enforcement of legislation by imposing fiscal and punitive measures.

Power Sector

In India, only 20 per cent of the total coal transported to the power plants are of superior grade with an ash content 24 per cent or less. The remaining 80 per cent is of an inferior grade with ash ranging from 24 to 45 per cent. Supply of high ash coal not only poses environmental problems but also causes poor plant performance and a high cost for transportation, operation & maintenance and ash disposal.

The Ministry of Environment and Forests (MoEF), Government of India (GOI) constituted a committee headed by the Chairman, CPCB, to suggest measures for

improving coal quality supplied to the power plants. On the recommendation of the Committee, GOI has promulgated a Gazette Notification [GSR 560(E) & 378(E)] on the use of beneficiated/blended coal containing ash not more than 34 per cent, which will be effective from June 2001 in the following power plants:

- Power plants located beyond 1000 Kms from the pit head;
- Power plants located in the critically polluted areas, Urban areas and in ecologically sensitive areas.
- Power plants using fluidized bed combustion (FBC) or integrated gasification combined cycle (IGCC) technologies are exempt to using beneficiated coal irrespective of their locations.
- CPCB has also suggested *third party & pit head* coal washing. It is estimated that pithead coal washing will increase the cost only by 2 to 3 per cent.

For the abatement of air pollution problems associated with coal mines, CPCB has developed National Environment Standards under the Environment Protection Act, 1986. Details of the Air Quality Standards are provided in Annexes 4 & 5.

As per a recent projection of the Central Electricity Authority there will be a requirement for an additional 100,000 MW of power by the year 2012, details of which is provided in Table 3.

Table 3: Power Generation- Projected Capacity Addition in MW.

	Coal	Gas/CCP	Nuclear	Hydro	Total
Installed Cap. As on 3/1999	57,159	10,114	1,840	22,299	91,412
Additional Cap. (1999-2012)	57,331	21,311	10,260	35,490	124,39
Total Cap. On 3/2012*	114,490	31,425	12,100	57,789	215,804

*Under Review

Hence it is evident that coal will remain the major fuel for power generation in India. Dependence of the power sector on inferior quality Indian coal has been associated with the emissions from the power plant of particulate matter, toxic elements, NO_x, CO_2 and fly ash. In addition large volumes of water are needed for cooling and there is a land requirement for ash disposal.

Since India cannot live without coal, one of the solutions is to adopt clean coal technologies, such as Circulating or Pressurized *Fluidized Bed Combustion (FBC), Supercritical Boilers and Integrated Gassification Combined Cycle (IGCC)* power plants which would not only mitigate the pollution problems associated with coal combustion, but also have higher thermodynamic efficiency. These technologies are very suitable for countries like India that possesses large deposits of low quality coal. Power generation from CNG, nuclear and renewables should also be encouraged.

Various long-term options for *green power* generation include Ultra Super-critical Boilers, Catalytic Gassification, Integrated gassification Combined Cycle (IGCC) with Hot Gas Clean-up, Integrated gassification Humid Air Turbine (IGHAT), Air Blown gassification Cycle, Hybrid Combined Cycles, Co-firing Coal with Biomass or Wastes, Fuel Cells, Cascade Humidified-air Turbines (CHAT), Direct Injection of Steam into the Gas Turbine (STIG), Heat Recovery using Endothermal Reforming plus Steam Injection (CHRISTIG), Heat Recovery using an Ammonia-water Working Fluid (Kalina Cycle) etc along with power generation from Coal Bed Methane.

Renewable Energy

India has a vast potential of renewable energy sources and a number of technologies have been developed to harness them. A sizable industrial base has been created in the country for the various renewable energy technologies such as solar thermal, solar photovoltaics, wind, small hydro and bio-energy. An aggregate capacity of about 1400 MW has been installed based on these technologies. The estimates of the potential from these sources as well as current status figures are outlined in Annex 6.

The annual turnover of the Renewable Energy Industry in the country, including the power generating technologies for wind and other sources, has reached a level of over Rs. 30,000 million. India has good know-how and technical knowledge in many renewable energy technologies. However, the infrastructure for large-scale development and deployment are not available compared to conventional form of energy, which was developed over the years.

Incentives for Promoting Renewables

- The Ministry of Non-Conventional Energy Sources (MNES) provides financial incentives, such as interest subsidies and capital subsidies. In addition, soft loans are provided through the Indian Renewable Energy Development Agency (IREDA), a public sector company of the Ministry and also through some of the nationalized banks and other financial institutions for identified technologies/systems.

- The Government also provides various types of fiscal incentives for the renewable energy sector, which include: 100% depreciation in the first year of the installation of the project; exemption/reduction in excise duty; exemption from the central sales tax; and customs duty concessions on the import of material, components and equipment used in renewable energy projects.

For creation of an attractive environment for evaluation and purchase, wheeling and banking of electrical energy generated from renewable energy sources, the Ministry has issued a set of guidelines to all the States. It has suggested that States should announce general policies for purchase, wheeling and banking of electrical energy generated from all renewable energy sources. Fourteen States have so far announced such policies in respect to various renewable energy sources.

Before 1991, because of subsidies on power to the agriculture and domestic sectors and also on middle distillates like kerosene and diesel, the consumer's preference was away from using renewable technologies because of the high initial investment cost.

But after economic reform and liberalization, one could expect that the renewable energy technologies would become economically viable.

Recently, the World Bank has been planning to provide financial support of about $130 million for small hydro projects being set up through private parties. The fund will be channeled through IREDA and is expected to add new capacity of about 200 MW. The World Bank has also decided to provide additional grant of $5 million to mobilize private participation in renewable energy projects.

New renewable energy policy is expected to add about 12,000 MW by the end of the 11th Plan, almost half of it from wind generation, 3500 MW from biomass and 2000 MW from small hydro. This capacity addition will require around Rs. 700 billion which will be obtained from union budget, taxes on coal and other fossil fuels and from World bank's grant.

According to Draft VII of the Electricity Bill 2000, co-generation and electricity generation from renewable sources will be promoted so that purchases therefrom constitute up to 10 per cent of the total electricity consumed in the authorized area of a distribution company, or such higher proportion as the state government may from time to time modify. The commission may determine a higher tariff to purchase renewable electricity provided that such tariff shall not exceed by greater than 20 per cent the tariff of a conventional thermal station in comparable circumstances.

Demand Side Management (DSM)

DSM can be looked upon either traditionally as a tool, to be used to change the demand for energy or more generally as a tool for the society for better use and distribution of scarce resources. There are two types of DSM projects:

- Energy Efficiency (EE): It focuses on modifications in end-use technology (e.g., lighting).
- Energy Conservation: It is synonymous with energy generation. Conservation is cheaper than incremental cost of energy production. This concept receives more prominence in today's Indian scenario, where building one MW of power generation costs as much as Rs. 3 to 4 crore whereas the same power can be saved with less investment. If the consequent benefits of rise in productivity are included, the net cost of energy conservation to the economy is much less.

Unfortunately, Indian industry has not paid much attention to energy savings in the past. The high-energy consumption in Indian industries is due to three main reasons:

- Most manufacturing units are still dependent on old machinery
- Relatively high cost of capital as compared to European/USA standards.
- There is uncertainty about the long-term growth of particular industrial sectors.

A recent World Bank report shows that Indian Industry has the potential to save 20 to 30 per cent of total energy consumption The following table indicates the average energy conservation potential in various sectors and in various energy intensive industries.

Table 4: Energy Saving Potential

Sector/Industry	Energy Saving Potential
Domestic & Commercial	20%
Transport	20%
Agriculture	30%
Industries	25%
Iron & Steel	10%
Fertilizers	15%
Textiles	25%
Cement	15%
Chlor-alkali	15%
Pulp & Paper	25%
Aluminum	10%
Ferrous Foundry	20%
Petrochemicals	15%
Glass & Ceramics	20%
Refineries	10%

(Source: CII Newsletter, Dec. 2000)

Energy conservation and efficiency improvement in the Indian power sector requires special attention since the sector has been suffering from a chronic supply shortage, lack of capital investment for new capacity addition and environmental problems associated with coal-based power plants. High auxiliary consumption and T&D loss further aggravate the problem.

Macroeconomic policies sometimes discourage the undertaking of energy efficiency measures. Environmentally harmful subsidies reduce the private costs of producers and consumers resulting in over-utilization of natural resources. Energy subsidies in India, for example, lead to energy intensive economic structures and technologies, and wasteful management practices. It has been estimated that the elimination of energy subsidies worldwide would reduce global carbon emission by 9.5%.

In the electricity sector, there is no incentive to encourage conservation, as a minimum charge is required to be paid by the consumers. Government should review the minimum charge concept levied by SEBs and other power utilities and consumer should be charged the actual costs for the consumption of power.

The energy audit program under the United Nations Department of Technical Cooperation for Development conducted by the Energy Management Center reveals that it is possible to save about 37,008 kiloliter of fuel oil, about 1,320,845 tones of coal and about 69.2 million kWh of electricity, which is in monetary terms equivalent to Rs. 424.2 million per annum. This constitutes 16 per cent of the energy bill of audited units.

Many DSM projects involve a combination of both energy efficiency and energy conservation measures that can result in low and no cost air pollution mitigation options. The level (and cost) of reduction is dependent on the source of electricity. If the electricity is generated by fossil fuels (e.g., coal, oil, natural gas), then the reduced demand shall translate into less generation and reduced level of emissions.

Section IV

Policy Instruments for Pollution Control

Policy instruments determine the style and cost-effectiveness of policy implementation and create a framework for financing mechanisms. Pollution prevention can be achieved by government's directly regulating pollution-generating activities (Command and Control Approach), or, indirectly, by influencing the decision making process on the micro level (economic instruments). Both these instruments can induce the polluters to finance pollution abatement from their own resources.

Command & Control (CAC) Approach

The CAC approach constrains polluting activities for each source uniformly by setting standards for technologies, processes or emissions. By setting and enforcing standards, the regulator can be assured that emissions and ambient quality will stay at a predetermined level.

A review of the evaluation of environmental policies in developed and some developing countries including India, shows that historically governments have tended to rely on CAC type policies for pollution control.

The CAC approach prevails for the following reasons

- Economists have played a minor role in administration.
- An economic approach is considered to be indirect with uncertain outcomes. The effects of regulation on environmental quality are more certain.
- Where finance is concerned, the revenues from charges are uncertain.
- Charges result in price increase, which may add to inflation.
- Charges might be considered as giving a right to pollute.
- The adversarial attitude on the part of some environmentalists who characterized pollution more as a moral failing of corporate and political leaders than a byproduct of modern civilization.
- The lobbyists' who have habituated with CAC approach are reluctant to allow any major changes.

However several empirical studies have demonstrated that CAC instruments are cost inefficient and sub-optimal in terms of social welfare maximization, i.e., they do not in general yield production- pollution-abatement outcomes which equate the social marginal benefit of abatement with its social marginal cost.

As a result, direct regulations are being gradually supplemented by economic instruments (EI) and taxes are increasingly used with the dual purpose of generating revenues and providing incentives for environmental improvements. EI may also create incentives for finding least-cost technologies and measures for prevention and control of pollution. However, in most cases, due to the influence of *industry lobby groups* the taxes are set too low to have any desired effect.

Economic Instruments

There are a number of economic instruments which are designed to internalize the external costs of pollution, make the polluter pay, and at the same time minimize the cost of a given level of abatement under given conditions with regard to tastes, production and abatement costs, etc. These are divided into two categories, direct and indirect economic instruments as shown in the table below.

Type	Direct	Indirect
1. Physical Instruments	Source-specific standards, non-tradable quotas for emissions/effluents, ban on hazardous materials	Restrictions on products and process, input uses, location of plants etc.
2. Economic Instruments	Emission / effluent charges, tradable pollution permits, user charges, deposit refund system, strict liability	Product charge, input charge, subsides for competitive outputs and sustainable environmental - friendly inputs, taxes on complementary outputs / inputs
3. Supportive Instruments	Development of environment - friendly technologies, technologies for conser- vation of environmental goods, common effluent treatment plant, recycling	Creation and enforcement of property rights, access to information about environmental problems, involvement of local public institutions and grass - root voluntary organizations in solving location specific environmental problems.

Source: Mehta et. al. (1997)

Direct economic instruments are preferred when the costs of observing, measuring, monitoring pollution levels are not high. Inter-plant variations in effluent/emission levels due to differences in the energy usage pattern, age of the plant, processes, raw materials etc. raise the costs of monitoring and measurement.

Indirect economic instruments involve less transaction costs in their implementation. It also generates the revenues that can be used to cover the part of the administrative expenses for regulation, development of clean technologies etc.

Choice of Instruments

It has already been pointed out that until recently pollution control largely depended on direct regulation. More recently while countries in Europe have introduced economic instruments mainly in the form of charges; the USA has gone ahead with economic instruments in the form of tradable pollution permits. *Therefore, there now exists a sufficient variety of experiences with different instruments to allow judgement about relative merits and demerits of the instruments.* It should be noted that regardless of the choice of the instruments or any combination of them, all require monitoring and enforcement. Unfortunately, the enforcement of environmental regulations in most developing countries is generally weak, frequently relying on self-regulation and warnings.

Section V

Sustainability & Clean Development Mechanism (CDM)

Sophisticated time series techniques like Co-integration Analysis and Granger's Causality Tests reveal the fact that in India, energy consumption causes economic growth without any feedback effect[3] (see *Masih & Masih, 1996; Ghosh, 2000*). So, a proper policy framework should be undertaken in the energy sector, to foster more investment, improved efficiency of use, diversification of energy supplies and cost-effectiveness of resource utilization for sustainable economic growth.

For two reasons, India is the focus of attraction to the world community. First, it may be the world's most populated country by 2025 and its green house gas (GHG) emissions would rise subsequently. Despite the fact that India emits only 0.2 tons per capita of carbon dioxide from fossil fuels (compared to 5.2 tons for the US and a world average of 1.2 tons), it is now the world's sixth largest carbon dioxide emitter. Second, the major share of India's energy comes from coal and it will continue to provide over 60% of the total energy in the future. But coal emits the highest amount of carbon dioxide. Coal has a carbon dioxide emission coefficient of 26 kg, while oil and gas have 21 kg and 16 kg respectively.

Thus, a high population, predominance of coal in energy use, low energy efficiency and a high potential economic growth because of current low-income level is causing concern in international circles about India's future GHG emissions. Under such circumstances, India would need to adopt sustainable energy efficient methods to reduce GHG emissions. But there is a major problem is getting finances for energy efficient technologies. Moreover, increasing foreign direct investment (FDI) flows continues to represent a national challenge for India. India's average annual FDI over 1991-1997 was even less than that of small countries such as Nigeria and Tonga while China succeeded in attracting over $28 billion a year in FDI over the same period. Further, a World Resources Institute (WRI) study says that by the late 90's, bilateral banks made up largely of Export Credit Agencies (ECAs) which accounted for 31% of all long-term financing received by developing countries, appeared to be investing heavily in projects resulting in long-term consumption and ultimately associated GHG emissions.

Though the picture seems quite discouraging, the above mentioned problems can be overcome. The "Flexibility Mechanisms" like CDM included in the Kyoto Protocol can be used to reduce emission levels. Such mechanisms are designed to be mutually beneficial to both the developed and developing countries. Investors from developed countries (also referred to as Annex B countries) could find projects that reduce GHG emission in a developing country. Developed countries therefore achieve emission reduction compliance at lower cost while developing countries benefit by achieving much-desired sustainable development path by getting access to finances and the state-of- the-art technology. The emission reductions in the developing countries can be

[3] Ref.

Ghosh, Sajal, 2000, Testing Co-integration and Causality between Energy Consumption and Economic growth in India. Forthcoming.

Masih, A. M. M. and Rumi Masih, 1996, Energy consumption, real income and temporal causality: results from a multi-country study based on cointegration and error-correction modeling techniques, Energy Economics 18, 165-183.

achieved in one of the following ways, as mentioned earlier, at costs much lower than in developed countries.

- Improving energy efficiency, thereby reducing emissions.
- Installing cleaner technology.
- Shifting to non-conventional sources of energy generation such as renewable energy.

Credit Rating Information Services of India Limited (CRISIL) conducted a study to examine the range of possibilities and investment potential for the Clean Development Mechanism (CDM) in India. The study used two approaches viz: top down approach and bottom up approach to arrive at investment potential estimates for India. The top down approach is based on global macroeconomic studies while the bottom up approach is based on detailed analysis of illustrative sectors in India.

The top down analysis shows that the CDM could account for between 397-503 million metric tons of carbon (MMtC) of emissions reduction required of Annex B continue in 2010 or between 33%-55% of the total reductions they are required to achieve. The corresponding CDM flows could be between $5.2-$17.4 billion. Using marginal costs of abatement in different countries to estimate the flow of CDM funds it is estimated that India would collect between 7%-12% of the total global market for CDM-led investment.

The bottom up approach develops an initial estimate of the investment potential for India via the CDM in selected sectors. Three sectors, which have the maximum potential for energy efficiency gains, are:

1. Electric Power Generation
2. Energy Efficiency Improvements in Industry
3. Transport

In some sectors two kinds of projects are possible:

- Correction Projects which involve replacement of an existing asset with energy efficient or emission efficient asset.
- Creation Projects which involve replacement of a proposed asset with energy efficient or emission efficient asset.

Impediments to Financing of CDM Projects

According to CRISIL[4], CDM projects, besides having the risks associated with conventional projects, have additional risks. Some of the factors impeding initial development of the CDM are the following:

- Uncertainty regarding the implementation of Kyoto protocol
- Risk of employing new and unproven technologies for emission reduction
- Returns not being commensurate with the underlying risk
- Uncertainly of valuation of CERs (Certified Emission Reductions) affecting the determination of project economics
- Risk of the project not being found CDM eligible after implementation

[4] Joshi Hemant, 2001, Project Structures for CDM projects, CII Newsletter, Vol. 3, No. 1

- In the absence of clear procedures, the transaction costs and implementation time could be high for initial CDM projects.

Hence the necessary conditions for the initial projects to be successful are:

a. Presence of investors who benefit from the CDM projects. The investors are likely to be those who are driven towards CDM projects by their existing business.
b. Ability to value the CERs since it would be essential for determination of project economics
c. Minimization of transaction costs and complexity in procedures.

Various project structures and participant profiles that could address the financing impediments, as suggested by CRISIL, are:

- Financing by corporations from developed countries
- Financing by equipment supplier
- Financing by fuel supplier
- Funding routed through Annex B (Developing Countries) Governments etc.

Section VI
Conclusion

India needs a sustainable energy policy that will not only meet the future energy demand for rapid economic growth but also protect the environment and conserve scarce resources. By making our thermal power sector more efficient, increasing the use of environmental management systems in energy-intensive industries, imposing stringent emission norms in transport and industrial sector, exploring alternative fuel vehicles, expanding the use of renewable energy technologies and introducing the Energy Conservation Bill, 2000 by GOI, India has already taken major steps in the right direction. Emphasis should also be given to enhancing regional energy security. There is still a great opportunity to do much more in these areas in a way that will benefit the economy as a whole.

The potential benefits of participating in efforts to address Climate Change are available now and in the immediate future. India could take advantage of these efforts to address Climate Change and thereby increase its foreign direct investment, technology transfer, and job creation while also taking a responsible step towards reducing environmental impacts. Thus changing development path now towards that supporting a cleaner environment can have many beneficial effects in the future.

Annex 1

Status of Reform & Restructuring of SEBs

(As of May 2001)

Parameters → / States ↓	State's decision to reform power sector	MoU with GOI	Reform bill		SERC			Unbundling of SEBs		Privatization Of distribution		Financial assistance procured from WB/ADB/ PFC etc.
			Proposed	Enacted	Decision taken to set up	Constituted	Functional	Envisaged	Done	Planned	Done	
Andhra Pradesh	✔	✔		✔			✔		✔	✔		✔ (WB)
Assam	✔	✔			✔							
Bihar	✔											
Delhi	✔			✔		✔				✔		
Gujarat	✔	✔	✔				✔	✔				✔ (ADB)
Goa	✔				✔							✔ (PFC)
Haryana	✔	✔		✔			✔		✔			✔ (WB)
Himachal pradesh	✔	✔					✔					
Jammu & Kashmir	✔											
Karnataka	✔	✔		✔			✔		✔	✔		✔ (WB)
Kerala	✔				✔			**Profit Center Approach**				✔ (CIDA)
Madhya Pradesh	✔	✔		✔			✔	✔				✔ (ADB)
Maharashtra	✔	✔	✔				✔	✔				✔ (PFC)
Orissa	✔			✔			✔		✔		✔	✔ (WB)
Punjab	✔	✔				✔						✔ (PFC)
Rajasthan	✔	✔		✔			✔		✔	✔		✔ (WB)
Tamil Nadu	✔					✔						✔ (PFC)
Uttar Pradesh	✔	✔		✔			✔		✔			✔ (WB)
West Bengal	✔	✔					✔					✔ (PFC)

Sources: Annual report 2000-2001, Ministry of Power, Power Line (September 2000)
Compiled by: Suman Kumar, Department of Business Economics, Delhi University

Annex 2

Indian Environmental Legislation

1. The Water (Prevention and Control of Pollution) Act, 1974, as amended up to 1988
2. The Water (Prevention and Control of Pollution) Rules, 1975
3. The Water (Prevention and Control of Pollution) (Procedure for Transaction of Business) Rules, 1975
    i. Constitution of Appellate Authorities
    ii. Delegation of Power as State Board by the Central Board
    iii. Central Water Laboratory to Various Union Territory Administrations
4. The Water (Prevention and Control of Pollution) Cess Act, 1977, as amended by Amendment Act, 1991
5. The Water (Prevention and Control of Pollution) Cess Rules, 1978
6. The Air (Prevention and Control of Pollution) Act, 1981, as amended by Amendment Act, 1987
7. The Air (Prevention and Control of Pollution) Rules,1982
8. The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983
    i. The Date from which the Act came into force
    ii. Declaration of Air Pollution Control Areas
    iii. Constitution of Appellate Authority

9. The Environment (Protection) Act, 1986
    i. Environmental laboratories and Analysts
    ii. Officers Authorized for taking Cognizance of Offences

10. The Environment (Protection) Rules, 1986
    i. Authorized Officers/Agencies to enter the Premises for Inspection
    ii. Officers/Agencies Authorized to take Samples
    iii. Emission Standards of Pollutants from various Industries
    iv. Guidelines for Location of Industries, Mining Operations etc. for various Areas
11. Environmental impact Assessment of Development Projects
12. Hazardous Wastes (Management and Handling) Rules, 1989
13. Manufacture, Storage and Import of Hazardous Chemical Rules, 1989
14. Manufacture, Use, Import, Export and Storage of Hazardous Micro-Organisms Genetically Engineered Organisms or Cells rules, 1989
15. Scheme of Labeling of Environment Friendly Products (ECO-MARKS)
16. Restricting certain activities Range in special Specified area of Aravalli
17. Bio-Medical Waste (Management and Handling) Rules, 1998
18. The National Environment Tribunal Act, 1995
19. The National Environmental Appellat Authority Act, 1997
20. The Environment (Protection) (Second Amendment Rules), 1999 - Emission Standards for New Generator Sets
21. The Public Liability Insurance Act, 1991
22. The Public Liability Insurance Rules, 1991
23. National Forest Policy, 1988
24. Forest (Conservation) Act, 1980
25. Forest (Conservation) Rules, 1981

26. The Eco Sensitive Zone - Pachmarhi, Notification, 1998
27. Recycled Plastics Manufacture and Usage Rules, 1999
28. 2-T Oil (Regulation of Supply and Distribution) Order, 1998
29. Coastal Regulation Zone - Notifications
30. Environment (Siting for Industrial Projects) Rules, 1999 - Notification
31. Taj Trapezium Zone Pollution (Prevent and Control) Authority - Order
32. Dumping and Disposal of Flyash - Notification
33. Noise Pollution (Regulation and Control) Rules, 2000
34. Municipal Solid Wastes (Management & Handling) Rules, 2000
35. Ozone Depleting Substances (Regulation) Rules, 2000
36. Batteries (Management & Handling) Rules, 2000 - Draft Notification
37. Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000 - Draft Notification
38. New Biodiversity Bill - 2000
39. The laboratories allowed to use of pathogenic micro-organism or genetically engineered organisms or cells for the purpose of research, 2000 - Notification
40. The Prevention and Control of Pollution (Uniform Consent Procedure) Rules, 1999 (Draft)

Annex 3

Emission Standards for New Generation Sets
MINISTRY OF ENVIRONMENT AND FORESTS

NOTIFICATION

New Delhi, the 5th October, 1999

88. Emission Standards for new generator sets (up to 19 kilowatt) run on petrol and kerosene with implementation schedule.

A. From June 1, 200

Class	Displacement (CC)	CO (g/kW-hr)		HC+NOx (g/kW-hr)	
		2-stroke engine	4-stroke engine	2-stroke engine	4-stroke engine
I	65	603	623	166	65
2	>65 , 99	-	623	-	36
3	>99 , 225		623		19.3
4	>225		623		16.1

B. From June 1, 2001

Class	Displacement (CC)	CO(g/kW-hr)	HC+Nox(g/kW-hr)
I	65	519	54
2	> 65, 99	519	30
3	> 99, 225	519	16.1
4	> 225	519	13.4

C. Test method shall be as specified in SAE J 1088. Measurement mode shall be D1 cycle specified under ISO 8178 (Weighting Factor of 0.3 for 100% load, 0.5 for 75% load and 0.2 for 50% load).

Annex 4

National Ambient Air Quality Standards

NOTIFICATION

Delhi, the 11th April, 1994

S.O. 384(E). The Central Pollution Control Board in exercise of its powers conferred under section 16(2) (h) of the Air (Prevention and Control of Pollution) Act, 1981(14 of 1981) hereby notify the National Ambient Air Quality Standards with immediate effect.

SCHEDULE - I

Pollutant	Time Weighted average		Concentration in ambient air		Method of measurement
		Industrial Area	Residential, Rural & other Area	Sensitive areas	
1	2	3	4	5	6
Sulphur Dioxide (SO_2)	Annual Average*	80 μg/m^3	60μg/m^3	15 μg/m^3	1. Improved West and Gaeke method
	24 hours**	120 μg/m^3	80 μg/m^3	30 μg/m^3	2. Ultraviolet fluorescence
Oxides of Nitrogen as NO_2	Annual Average*	80 μg/m^3	60 μg/m^3	15 μg/m^3	1. Jacob & Hochheiser modified (Na-Arsenite) Method
	24 hours**	120 μg/m^3	80 μg/m^3	30 μg/m^3	2. Gas Phase Chemiluminescence
Suspended Particulate Matter (SPM)	Annual Average*	360 μg/m^3	140 μg/m^3	70 μg/m^3	
	24 hours**	500 μg/m^3	200 μg/m^3	100 μg/m^3	(Average flow rate not less than 1.1 m3/minute).
Respirable Particulate matter (size less than 10 um)(RPM)	Annual Average*	120 μg/m^3	60 μg/m^3	50 μg/m^3	
	24 hours**	150 μg/m^3	100 μg/m^3	75 μg/m^3	
Lead (Pb)	Annual Average*	1.0 μ/m^3	0.75 μg/m^3	0.50 μg/m^3	--AAS Method after sampling using EPM 2000 or equivalent filter paper
	24 hours**	1.5 μg/m^3	1.00 μg/m^3	0.75 μg/m^3	
Carbon Monoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/m^3	--Non dispersive infrared spectroscopy
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24hourly/8hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Annex 5

Air Quality Standards for Coal Mines

The Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Sulphur dioxide (SO_2) and Oxides of Nitrogen (NOx) concentrations at downwind direction at considering predominant wind direction at 500 m from the following dust generating sources shall not exceed the standards given in Tables I, II and III.

Table I

Category	Pollutant	Time weighted Avg.	Concentration in Ambient Air	Method of Measurement
1	2	3	4	5
New Coal Mines (Coal Mines coming up after Dec. 1998)	Suspended Particulates Matter (SPM)	Annual Average* 24 hours **	360 μg/m^3 500 μg/m^3	High Volume Sampling (Average flow rate not less than 1.1 m^3 /minute)
	Respirable Particulate Matter (size less than 10m) (RPM)	Annual Average* 24 hours **	180 μg/m^3 250 μg/m^3	Respirable Particulate Matter
	Sulphur Dioxide (SO_2)	Annual Average* 24 hours **	80 μg/m^3 120 μg/m^3	1. Improved west and Gaeke method 2. Ultraviolet fluorescence
	Oxide of Nitrogen as NO_2	Annual Average* 24 hours **	80 μg/m^3 120 μg/m^3	1. Jacob & Hochheiser Modified (Na-Arsenic) Method 2. Gas phase Chemilumine-scence

Table II

Category	Pollutant	Time weighted Avg.	Concentration in Ambient Air	Method of Measurement
1	2	3	4	5
Existing coal fields/mines given below: Karanpura, Rangarh, Giridih, Rajhara, Wardha, Nagpur, Silewara, Pench Kanhan, Patharkhera, Umrer, Korba, Chirimiri, Central India Coalfields (including Baikunthpur, Bisrampur), Sinrauli, 1b Valley, Talcher, and Godavary – Valley coalfields	Suspended Particulates Matter (SPM)	Annual Average* 24 hours **	430 $\mu g/m^3$ 600 $\mu g/m^3$	High Volume Sampling (Average flow rate not less than 1.1 m^3 /minute)
	Respirable Particulate Matter (size less than 10m) (RPM)	Annual Average* 24 hours **	215 $\mu g/m^3$ 300 $\mu g/m^3$	Respirable Particulate Matter
	Sulphur Dioxide (SO_2)	Annual Average* 24 hours **	80 $\mu g/m^3$ 120 $\mu g/m^3$	1. Improved west and Gaeke method 2. Ultraviolet fluorescence
	Oxide of Nitrogen as NO_2	Annual Average* 24 hours **	80 $\mu g/m^3$ 120 $\mu g/m^3$	1. Jacob & Hochheiser Modified (Na-Aresnic) Method 2. Gas phase Chemilumine-scence

μg: micro-gram

Table III

Category	Pollutant	Time weighted Avg.	Concentration in Ambient Air	Method of Measurement
1	2	3	4	5
Old Coal Mines - Jharia - Raniganj - Bokaro	Suspended Particulates Matter (SPM)	Annual Average* 24 hours **	500 μg/m^3 700 μg/m^3	High Volume Sampling (Average flow rate not less than 1.1 m^3 /minute)
	Respirable Particulate Matter (size less than 10m) (RPM)	Annual Average* 24 hours **	250 μg/m^3 300 μg/m^3	Respirable Particulate Matter
	Sulphur Dioxide (SO_2)	Annual Average* 24 hours **	80 μg/m^3 120 μg/m^3	1. Improved west and Gaeke method 2. Ultraviolet fluorescence
	Oxide of Nitrogen as NO_2	Annual Average* 24 hours **	80 μg/m^3 120 μg/m^3	1. Jacob & Hochheiser Modified (Na-Aresnic) Method 2. Gas phase Chemilumine-scence

μg: Micro-gm.

Annex 6

Renewable Energy Potential & Achievement

(As of December 31, 2001)

Sources/Technologies	Unit	Approximate Potential	Status
Power from Renewables:			
Wind	MW	45,000	1267 MW
Small Hydro (up to 25 MW)	MW	15,000	1341 MW
Biomass / Bagasse based co-generation	MW	19500	273 MW
Solar Photovoltics Power	MW/Sqkm	20	47 Mwp
Solar Energy Applications			
Aggregate Annual Production of PV Module MW			11 MW
Solar Water Heating systems	Sq mtr Collector area	1400 lakh Sq. Kms	5.5 lakhs
Solar Cookers	Nos		4,66,674
Energy Recovery from Wastes:			
Urban & Industrial waste	MWe	1,700	15.15 MWe
Energy for Rural Area:			
Biogas Plants	Nos	12 million	3.128 million
Improved Chulha	Nos	120 million	32.89 million

(Source: Ministry of Non-conventional Energy Sources [MNES])

Glossary

Abbreviations

CAC	Command and Control
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CERC	Central Electricity Regulatory Commission
CNG	Compressed Natural Gas
CO	Carbon monoxide
CPCB	Central Pollution Control Board
CRISIL	Credit Rating Information Services of India Ltd.
DSM	Demand Side Management
FBC	Fluidized Bed Combustion
GDP	Gross Domestic Product
GHG	Green House Gases
GTCC	Gas Turbine Combined Cycle
IGCC	Integrated Gassification Combined Cycle
IREDA	Indian Renewable Energy Development Agency
koe	Kg. Of Oil Equivalent
MoEF	Ministry of Environment & Forests
MW	Mega watt
Nox	Oxides of Nitrogen
O & M	Operation and Maintenance
PLF	Plant Load Factor
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
Sox	Oxides of Sulfur
SPM	Suspended Particle Matter
T & D	Transmission and Distribution
TERI	Tata Energy Research Institute
TWh	Trillion Watt Hour
TPD	Ton per Day
VOC	Volatile Organic Compound

Conversion Factors

1 Crore	=	10 Million
10 Lakh	=	1 Million
1 Calorie	=	4.18 Joule
1000 kWh	=	3.6 Giga Joule (GJ)
1 Tonne of Oil Equivalent (toe)	=	42 GJ
1000 KWh	=	0.086 toe
1000 m^3 of Natural Gas	=	36 GJ
1000 m^3 of Natural Gas	=	0.857 toe
1$	≈	Rs. 46

Energy GDP Causality

Since 1970's causal relationship between energy consumption and economic growth has been the prime focus of economists and policy analysts where the central issue is: does economic growth stimulates consumption of energy or can energy consumption itself be a stimulus for economic growth via the indirect channel of effective aggregate demand, improved overall efficiency and technological progress. Such knowledge can play a crucial role from policy formulation point of view. For example, *existence of unidirectional causality running from income to energy consumption implied* that energy conservation policies may be initiated without deteriorating economic side effects. For theoretical details please consult any standard "Time Series Analysis" book.

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4. Statistical Yearbook 2000, CII.

5. Web Sites of
   a) Ministry of Environment & Forest (http://envfor.nic.in)
   b) Ministry of Power (http://powerin.nic.in)
   c) Ministry of Coal (http://coal.nic.in)
   d) Ministry of Non-conventional Energy Sources (http://mnes.nic.in)
   f) Central Pollution Control Board (http://envfor.nic.in/cpcb/)
   h) TERI (www.teriin.org)
   i) Power Line (www.indiapoweronline.com)
   j) CII (www.ciionline.org)

Confederation of Indian Industry

The Confederation of Indian Industry works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes.

CII is a non-government, not-for-profit, industry led and industry managed organisation, playing a proactive role in India's development process. Founded over 100 years ago, it is India's premier business association, with a direct membership of over 3900 companies from the private as well as public sectors, including SMEs and MNCs and indirect membership of 40,000 companies of over 100 sectoral associations.

A facilitator, CII catalyses change by working closely with government on policy issues, enhancing efficiency, competitiveness and expanding business opportunities for industry through a range of specialised services and global linkages. It also provides a platform for sectoral consensus building and networking. Major emphasis is laid on projecting a positive image of business, assisting industry identify and execute corporate citizenship programmes.

With 30 offices in India, 10 overseas in Austria, France, Germany, Hong Kong (China), Hungary, Israel, Singapore, South Africa, UK & USA and institutional partnerships with 191 counterpart organisations in 92 countries, CII serves as a reference point for Indian industry and the international business community.

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