EU-India Cooperation on Climate Change

STUDY ON ENVIRONMENT AND ENERGY IN INDIA

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CONTENTS

ANNEXES

COMMONLY USED ABBREVIATIONS AND ACRONYMS

AIRPET	Asian Regional Air Pollution Research network
AQM	Air Quality Management
AQMS	Air Quality Management System
CAAQM	Continuous Ambient Air Quality Monitoring
CAAQMS	Continuous Ambient Air Quality Monitoring Station
CDP	The Carbon Disclosure Project
CMA	Cement Manufacturers Association
CMB	Chemical Mass Balance
CO	Carbon Monoxide
CPCB	Central Pollution Control Board; under MoEF
CREP	Corporate Responsibility for Environmental Protection
Crore	10,000,000
CSE	Centre for Science and Environment
EIA	Environmental Impact Assessment
EMS	Environmental Management System
ESP	Electrostatic Precipitator
GAINS	Greenhouse Gas and Air Pollution Interactions and Synergies
GHG	Greenhouse gasses
GoI	Government of India
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeeit; the German development assistance organization
IIT	India Institute of Technology
IITM	Indian Institute of Tropical Meteorology
ISC	Industrial Source Complex
ISCLT	Industrial Source Complex Long Term
ISCST	Industrial Source Complex Short Term
Lakh	100,000
MoEF	Ministry of Environment and Forests
MoP	Ministry of Power
MT	Million tonnes
NAMP	National Air Quality Monitoring Programme
NatCom	National Communication to United Nations Framework Convention on Climate Change (UNFCCC)
NEERI	National Environmental Engineering Research Institute
Nm^3	Normal cubic metre; at atmospheric pressure and 15 ^oC.
NOx	Nitrogen Oxides
NTPC	National Thermal Power Corporation
PAH	Poly-Aromatic Hydrocarbons
PAN	Peroxy Acetyl Nitrate
PBN	Peroxy Benzile Nitrate
PM10	Particles less than 10 micrometres
PM2.5	Particles less than 2.5 micrometres
RSPM	Respirable suspended particulate matter
SAIL	Steel Authority of India Ltd.
SME	Small and Medium-size Enterprise; in this report used as synonymous with small and medium-size industry
SOx	Sulphur Oxides
SPCB	State Pollution Control Board
SPM	Suspended particulate matter
TERI	The Energy Research Institute
TSP	Total suspended particles
USEPA	United States Environment Protection Agency
WB	The World Bank
WBCSD	World Business Council for Sustainable Development
WBPCB	West Bengal Pollution Control Board

EXECUTIVE SUMMARY

Indian capacity to monitor atmospheric emissions from large industrial and power generation sources

Indian capacities to monitor atmospheric pollutions from large industrial and power generation sources have been assessed. Atmospheric pollutions include greenhouse gasses (GHG). Because of the time limit, main conclusions are drawn based on the experience of two major industrial sectors in terms of production and pollution - steel and cement.

India has fairly good regulatory and legislative frameworks and institutional set-up to manage environmental hazards. Responsibility is shared between the centre and the States, with the central government having responsibility for policy and regulatory formulations and the State governments for ensuring implementation and enforcement of national policies and laws.

Despite regulatory and institutional frameworks in place, environmental management and monitoring pose great challenges. While most of the problems are related to implementation, better laboratory facilities, capacity for sampling, experiment and analyses could improve the quality of monitoring and standards specification. Given the size of the country, in order to cope with the growth of the complex industries such as steel, chemicals etc, it will be necessary to increase the number of laboratories to make the facilities easily accessible. R&D activities need to be strengthened, e.g. through international assistance in the form of technical cooperation.

Calibration and maintenance of monitoring equipment are generally done by the foreign suppliers, as the country has few facilities to manufacture such equipments. There are no specified standards for monitoring equipment. Given the large market potential, manufacturing of automatic monitoring systems locally would help to develop local technical capacity and knowledge to reduce the problems of maintenance and calibration. An additional measure would be to establish a central institute with authority and capacity for calibration and standardization.

Generally, new investments in large industrial projects bring modern and clean technologies, and big companies, particularly those operating in the global market, increasingly adhere to sound management practices.

GHG emissions are not regulated; industries do not need to report GHG emissions or comply with any standards and therefore industries do not monitor GHG. However, some initiatives in this front are taken recently, primarily from international interests or initiatives from some national NGOs.

India's second National Communication to the UNFCCC under preparation. India's Initial National Communication had considerable uncertainties in the emissions estimates from various sectors, in particular the industrial sector. Proper measurements and improved methodologies are needed to improve the quality and accuracy of emission factors.

Indian capacity to monitor atmospheric concentrations of air pollution

Indian capacities to monitor atmospheric concentrations of air pollution and to assess the contribution of the above mentioned emissions to air pollution, e.g. through modelling, have been analysed.

Air Quality Monitoring

The Central Pollution Control Board (CPCB), the central regulatory authority on pollution related matters, is executing a nation-wide National Air Quality Monitoring Programme (NAMP). Over the years, monitoring stations have increased in number and the capabilities for monitoring have improved through various capacity building initiatives supported by the Government and also through bilateral cooperation.

CPCB has laid down national standards on ambient air quality and source specific emission standards. Four air pollutants - Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2, Suspended Particulate Matter and Respirable Suspended Particulate Matter - are monitored at all locations, while, PAHs, NH_3, H_2S are monitored in few cities. Main focus is urban areas, in particular mega-cities, where rapidly increasing vehicle populations make it difficult managing urban air quality.

In addition to the manual air quality monitoring network, continuous monitoring systems have also been established at various places, which provide instantaneous information on pollution levels. In order to make these data available to public on real-time basis, a network for online real-time data transmission has been established at CPCB. Air quality data can be accessed through CPCB's website.

Although India has a fairly extensive monitoring programme, the system needs to be modernised according to international standards. Monitoring stations needs to be made automatic to improve accuracy, reliability and the possibility to develop alert systems in the case of pollution peaks. In addition to the development of air quality forecast systems and procedures, standardization at the national level the monitoring and quality control procedures are needed. Other steps include setting up of a valid and quality controlled local and central air quality database, and a standardized data transfer and data processing system that enable a free flow of information between cities, central government and eventually the public.

India has scientific and technical capacity to conduct monitoring activities. However, it is neither adequate nor proportionally distributed regionally.

Air Quality Modelling

Application of air quality modelling to manage local air quality is increasing in India. Of late, India is also taking part in several regional and international initiatives that apply models to understand close links between abatement strategies of local air pollutions and GHG emissions, and trans-boundary transport of air pollutions.

Modelling activities are generally carried out in isolated manner across different institutes and sharing information and knowledge is poor, causing repetitions of work. More network activities are also needed, both within R&D and between research institutions and policy making and regulatory bodies.

Urban air quality modelling

The most commonly used air quality models include the following:

Dispersion Modelling. These models are typically used in the permitting process to estimate the concentration of pollutants at specified ground-level receptors surrounding an emissions source. Dispersion modelling is widely used by the regulatory agencies as well as academic and research institutions. In many occasions, the used models do not suit under Indian conditions and cannot be changed since source codes are not available.

Receptor Modelling. These models are observational techniques which use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations. Receptor modelling is gaining importance in India. Source apportionment studies have been initiated in six major cities. Source apportionment studies track down the sources through emissions profiling, and receptor modelling help in identifying the sources and extent of their contribution.

Regional Modelling

The EC-funded GAINS model combines energy use, sulphur dioxide emissions, abatement approaches and emission control strategies, a long-range transport model for dry and wet deposition of sulphur dioxide and sulphate, and regional environmental effects of sulphur deposition. GAINS allows the assessment of emission control costs for the six greenhouse gases covered under the Kyoto Protocol together with the emissions of air pollutants.

Global modelling

The Indian Institute of Tropical Meteorology (IITM) uses a global chemistry transport model to investigate the special behaviour in the distribution of boundary layer ozone and its precursors.

With growing economic activities and population, air pollution in India is going to increase manifold, causing concern in terms of trans-boundary pollutions. Increased participation in international initiatives will be beneficial for both India and the international communities.

Combined benefits of reducing greenhouse gas emissions and improving air quality

There are several win-win potentials, or co-benefits, to be gained from implementing climate change policies, as well as climate change benefits to be gained from policies in other areas:

1. The main greenhouse gas CO_2 and other air pollutants stem to a large extent from the same sources, the burning of fossil fuels. Studies have indicated the number of premature deaths associated with air pollution in the range of 40,000 to 50,000. The number of human lives saved per million tonnes of carbon abated exceeds 300.

2. A study in Hyderabad found that the transportation sector offers the greatest opportunity for human health improvements and greenhouse gas reductions.

3. Some greenhouse gases, such as methane, are precursors for ground level ozone. An analysis of ozone in the Indian sub-continent concluded that surface ozone is much above critical levels, significantly influencing agricultural productivity in most places of India, with estimated crop yield reductions considerably above 5 percent.

4. In the power sector several potential benefits go hand-in-hand, i.e. efficiency increase, availability improvement, reduction in O&M costs, less capacity addition, less raw materials and fuels required, increased profitability and reductions in GHG emissions. This has been fully demonstrated by a programme operated by the National Thermal Power Corporation since the mid 1990'es.

5. Public concern about the environment can strengthen the market pressures favouring 'green' companies. New companies may take environmental leadership and put existing firms in a competitive disadvantageous position. Large Indian industries understand this, and various initiatives are on-going to harness this co-benefit of reducing air emissions.

Focus in India is still on other priorities such as economic growth, air quality management and energy security. The co-benefits approach for India would then not be climate-centric but could be e.g. energy-security centric (for Government), energy-efficiency centric (for industries) and air-quality centric (for the general public).

A few studies have examined the potential co-benefits from limiting growth of greenhouse gasses in India. Focus has been on air quality and the health of urban populations. By valuing this co-benefit, emissions could be reduced about 10 – 15% per cent without incurring net costs. The GAINS project is probably the most comprehensive attempt to estimate the co-benefits of improved air quality and greenhouse gas mitigation for India (among other countries). The study includes economic costs and benefits until 2030. The project and its results are little known outside a few academic institutions, and it is therefore recommended that the project outcome be disseminated widely, not the least to policy makers and public authorities.

Pilot projects

Two candidate pilot projects to be implemented under the EU-India Initiative on Clean Development and Climate Change have been conceptualized. The aim of the pilot projects is to build Indian capacity to monitor and report classic air pollutants and greenhouse gas emissions. At the same time, potential win-win benefits of climate change and air quality/health policies shall be high-lighted. The key features of the two projects are:

World-class air pollution and climate change modelling

The objective is to strengthen Indian participation in the development of state-of-the-art air pollution and climate models. This will be achieved by:

1. Increasing capacities in measurements/monitoring and emission inventories;

2. Increasing capacities and synergies in air quality modelling;
3. Facilitating the development of regional chemistry-transport models;
4. Facilitating integration of the various disciplines within air pollution measurement and modelling;
5. Supporting stronger participation in pertinent international activities;
6. Enhancing capacities in forecasting air pollution and impacts (incl. economic consequences and climate change), thereby improving the basis for air pollution control policies and strategies.

Greenhouse gas emission factors at iron & steel and cement plants

The objective is to improve the greenhouse emission factors used for India's reporting to UNFCCC (the national communications). The project will focus on two industrial sub-sectors: Iron and steel production and cement production. It is suggested that actual measurements and analyses are carried out in twinning arrangements between Indian and European institutions. Proposed approach:

1. A small number of representative manufacturers within each industrial sub-sector is selected. The manufacturers should be grouped according to technology or energy/environmental performance.
2. Data collection is conducted at each industry to arrive at plant-specific emission factors.
3. The plant-specific emissions are benchmarked nationally and internationally, and suggestions to improve the environmental performance are elaborated. Focus shall be on initiatives, which are cost-effective and attractive to the specific industries.
4. The plant-specific emission factors are used to develop national default values, possibly technology-specific.

Perceptions and expectations of EU-India cooperation in climate change

Perceptions and expectations of the EU-India cooperation in the climate change field have been briefly assessed. The major conclusions were:

- EC sponsored activities in climate change should be mainstreamed into development projects and programmes.
- The main thrust should be implemented as long-term working relations on the ground, targeting tangible results (i.e. more than studies and traditional capacity building).
- An efficient means may be to partner with those EU Member States, which have profound, long-lasting and pertinent programme activities in India.

1. INTRODUCTION

1.1 FRAMEWORK

The EU-India Summit in New Delhi, 7 September 2005, agreed to establish the "India-EU Strategic Partnership - Joint Action Plan", (http://ec.europa.eu/external_relations/india/sum09_05/index.htm).

As part of this Action Plan, the parties agreed to launch an "EU-India Initiative on Clean Development and Climate Change". The Initiative focuses on voluntary practical measures, and is taken forward at successive EU-India summits. In view of the particular importance of cleaner technologies for tackling climate change, both sides further agreed to:

- Identify and develop ways of widening access and overcoming the barriers to dissemination of such technologies in India and the EU and more widely;
- Increase funding and promote public-private partnerships for research and development of cleaner technologies;
- Promote adaptive research and development to suit the resource endowment of both parties;
- Reduce the price gap between "cleaner" and "less efficient" technologies by seeking economies of scale;
- Hold experts' meetings on climate change, including on the Clean Development Mechanism (CDM).

It was further decided that India and the EU would take steps to encourage and promote sustainable patterns of consumption and production to lessen the causes and adverse impacts of climate change.

Both sides also agreed to cooperate to enhance the scientific, technical and institutional capacity to predict climate change and its socio-economic impacts. Research and development on technologies and measures to adapt to climate change are being pursued by India and the EU.

The European Commission is continually developing activities under the umbrella of this Initiative to step up its cooperation with India. As part hereof, the Commission launched in January 2008 the present 'Study on environment and energy in India,' ,assigning the consultant company HTSPE Ltd. (www.htspe.com), United Kingdom, to conduct the study over a period of 6 months.

1.2 OBJECTIVE

The overall objective of the Study is:

> Building on recent and ongoing work in other fora, determine Indian capacity to monitor atmospheric pollution from large industrial and power generation sources, develop an overview of potential win-win benefits of climate change and air quality/health policies, and design a pilot project to strengthen monitoring and reporting capacity for atmospheric emissions from those sectors in India.

The Study shall deliver 5 sub-reports. The specific objectives of each of these reports are:

Sub-Report 1

> Assess the Indian capacity to monitor atmospheric emissions of key pollutants including greenhouse gases from large industrial and power generation sources.

Sub-Report 2

> Analyse the Indian capacity to monitor atmospheric concentrations of air pollution and the capacity to assess the contribution of the above mentioned emissions to air pollution, e.g. through modelling.

Sub-Report 3

> Building on projects funded by EU's Framework Programme for research, technological development and demonstration activities, such as RAINS and GAINS Asia, summarise the win-win (mitigation + air quality) potentials of tackling these environmental impacts.

Sub-Report 4

> Design a possible and feasible pilot project in one (or more) of these sectors with the aim of building Indian capacity to monitor and report classic air pollutants and GHG emissions, to be

implemented under the EU-India Initiative on Clean Development and Climate Change, which could be funded under the forthcoming Country Strategy Paper and the National Indicative Programme (2007-2013) for India, indicating potential partners where appropriate.

Sub-Report 5

Assess and analyse perceptions and expectations on both sides. An overview should be given of the perceptions and expectations of EU-India cooperation in the climate change field.

2. INDIAN CAPACITY TO MONITOR ATMOSPHERIC EMISSIONS FROM LARGE INDUSTRIAL AND POWER GENERATION SOURCES

2.1 BACKGROUND INFORMATION

2.1.1 General

For over a decade, from the early 1990s, India has experienced one of the fastest economic growth rates in the world, averaging over 6 percent and reaching 7-8 percent per year since 2003 (WB, 2007). This growth has had a dramatic impact on the country's environment and natural resources.

The growth of India's economy is led by the robust performance of the industrial sector*.* Impressive growth in manufacturing (7 percent average over the past 10 years) is a reflection of growth trends registered in sectors like electronics and information technology, textiles, pharmaceuticals, and basic chemicals. Excepting electronics and IT, these industries, belong to the "red category" of major polluting processes designated by the Central Pollution Control Board (CPCB), and have significant environmental consequences in terms of water effluents and/or air emissions and hazardous wastes. The economic boom has also led to an increase in investments and activities in the construction, mining, and iron and steel sectors. This, in turn, is causing a significant increase in brick making units, cement plants, sponge iron plants and steel re-rolling mills that use [potentially] highly polluting processes. The result is a visibly deteriorating environmental quality in many industrial townships, bringing back memories of earlier industrializations in the 1960s and 1970s (Box 1) and highlighting the importance of stepping up efforts to manage the externalities of accelerated growth.

Box 1: The Singrauli Region: Legacy of Industrial Development

Located about 1000 km southeast of Delhi, the Singrauli region was, until the early 1960s, a relatively isolated rural and economically under-developed region. Today Singrauli's landscape is dominated by massive open-cast coal mines (producing 50 million tons per annum and with enough reserves to triple the region's current production), six thermal power stations with operating capacity of 7,800 MW, installed hydro power capacity of 400 MW, a significant number of large public and private energy-dependent heavy industries (including cement, aluminum (150,000 tons per annum), caustic soda (33,000 tons per annum), and a number of other small and medium ancillaries), power transmission towers, belching smokestacks, quarries, and a number of crowded, congested and polluted urban centers ("Boom Town Effect"). The region is a remarkable example of what almost half a century of induced development without adequate social and environmental safeguards can produce: a much needed economic productivity and corresponding severe social depravation/fragmentation and environmental degradation. Air and water pollution are of great concern, especially the presence of mercury in the food chain and other chemicals and heavy metals in water resources.

In 1991, the Government of India (GoI) designated the region as a critically polluted zone, for which a comprehensive remedial Action Plan has to be developed and implemented. Environmental management plans were designed for each of the local industries, with a significant level of monitoring and oversights from environment and local authorities.

An apex Committee was set up headed by a Chairman, Special Area Development Authority (SADA), for regular review of progress. Recent evaluation shows that the situation has improved to some extent with respect to compliance with the Action Plan recommendations. The Committee further recommended better monitoring of air and water quality in the long term that includes undertaking an assessment of the carrying capacity of the region, adopting cleaner coal technologies, and environmental capacity building.

(Source: Bose and Leitmann, 1996) in WB, 2007

This scale of development cannot happen without significant growth in power generation. The power sector is associated with a host of environmental externalities, manifested at different spatial levels — local, regional and global (Box 2). The key environmental concern for India is linked to heavy reliance on coal, which accounts for about 60 percent of power generation. While special efforts are made by the Government of India to increase the share of hydro and other alternative energy sources, coal is likely to remain the dominant fuel for many years given India's vast indigenous coal resources.

Box 2: Key Environmental Issues in the Power Sector

- Coal-based thermal power has significant environmental effects due to gaseous emissions, particulate matter, fly ash and bottom ash, and water effluents. The impact is further exacerbated by the high ash content of India's coal and aging facilities lacking modern pollution control;

- One of the most serious effects of coal power stations is land requirement for ash disposal and percolation of hazardous elements into ground water through ash disposal in ash ponds. Due to enormous quantity of ash content in India's coal, approximately 1 acre per MW of installed thermal capacity is required for ash disposal. If this trend continues, by the year 2014–2015, 1000 square km of land, equal to the size of the Honk Kong area, or 1 square meter per person, should be required for ash disposal only;

- Coal-based generation is also the main contributor to India's carbon dioxide emissions, linked to changes in global climate.

Source: WB, 2007

Despite an enabling legislation and progress in institutional development, keeping up with the environmental challenges of rapid urban growth, industrialization, and infrastructure development (including provision of adequate environmental infrastructure to booming urban areas) has proved to be difficult. This is evident from the persistent high levels of environmental pollution in excess of national ambient standards. In 2003, of the nearly 3,000 ambient water quality observations, the levels of prevalent organic pollution, measured as biochemical oxygen demand (BOD), exceeded water quality criteria for Class A water bodies in over 1,000 cases. The country-wide ambient air quality monitoring carried out by CPCB at 201 monitoring stations revealed that National Ambient Air Quality Standards (NAAQS) for respirable suspended particulate matter (RSPM), the main air pollutant of public health concern, were violated at most of the monitoring stations (MoEF, 2005). The estimated annual economic cost of damage to public health from increased air pollution, based on RSPM measurements for 50 cities with the total population of 110 million, reached US$ 3 billion (Rs.15,000 crores) in 2004 (reported in WB, 2007). Along with industrial growth, energy demand is also growing and so are energy related GHG emissions. As an emerging economy with a steeply increasing demand for energy, India is a key partner in the fight against climate change. India is a Party to the Kyoto Protocol, but as a developing country, it does not have a binding emission limitation or reduction target. In countries such as India where classic air pollutants are still a key policy issue, action on SOx, NOx and particulates (e.g. through often reduction in energy consumption in industrial units) often also implies a co-benefit of reduced CO2 emissions. In order to assess the effect of emission reduction measures in terms of climate and air quality, and hence to realize the potential of win-win policies, it is essential to monitor emissions as well as the atmospheric concentrations of air pollutants in the atmosphere. This is a key challenge for developing countries such as India where there is great scope for improving the understanding of the relationship between emissions and atmospheric concentrations of key pollutants.

2.1.2 Large industries

India has fairly large industrial sector which has grown over years. In 2005, the industrial sector contributed about 24% of GDP. Between 1999 and 2004, the industrial sector's value added has grown at the rate of about 7% per annum. Even higher growth rates are expected in the future as a result of projected overall high economic growth rate of 8-9% annually. To address the environmental challenges in coordination with the state governments, the central government has identified and targeted 17 highly polluting industries and 24 environmental problem areas. The chemical and engineering industries are at the top of the government's list, since they are the major contributors to air, water, and waste pollution. These industries include integrated iron and steel plants, non ferrous metallurgical units, pharmaceutical and petrochemical complexes, fertilizers and pesticide plants, thermal power plants, textiles, pulp and paper, tanneries and chloroalkali units (OECD, 2006). Brief descriptions of some of these industries which have large production base in the country with high future growth potential are presented in the following sections. These industries include:

- Iron and steel
- Cement
- Chemicals
- Textiles
- Aluminium
- Paper and pulp

Table 1: Production trends from large energy intensive industries

	Unit	1980	1990	2000	2005
Steel	Mt	6.8	13.5	31.2	44.4
Cement	Mt	18.6	48.8	99.2	140.6
Chemicals	Mt	4.2	11.4	18.04	20.0
Textiles	Million sq. mt.	10988	22937	40233	49577
Aluminium	Mt	0.2	0.0.45	0.62	0.56
Paper	Mt	1.15	2.1	3.1	3.9

Source: GOI, 2007

Table 1 shows the production trends of these large industries. These industries are energy intensive too. These industries together consume about 75% of the industrial sector's energy consumption and nearly 20% of the energy consumed in the entire economy.

Iron and Steel:

Driven by domestic demand, and with abundant iron ore resources and a well-established base for steel production in the country, steel is poised for growth in the coming decades. The rapid rise in production has resulted in India becoming the world's 5th largest producer of steel, up by two places[1]. The production of finished steel grew by 16.5 per cent, from 44.5 million tonnes (MT) in 2005-06 to 49.4 MT in 2006-07. In addition, pig iron production stood at respectively 2.6 MT. By 2005, India's sponge iron capacity was 17 MT up from 1.3 MT in 1991/92. The domestic average growth rate has been 21 per cent in the last three years while the global growth rate stands at 10 per cent.

The government plans to increase annual steel production from the present 53 MT to 124 MT by 2011 and 200 MT by 2020, so as to narrow the gap between supply and demand. India is poised to be the world's 2nd largest producer of steel before 2016. Tata Steel, the world's fifth largest steel maker, plans to double its capacity by 2015, by adding another 35 MT capacity. India's largest steel manufacturer state-owned Steel Authority of India Limited (SAIL) is planning to increase its annual production of 12 MTPA to 24.98 MTPA by 2011-12.

The Indian steel industry is organized in three categories, i.e. main producers, other major producers and the secondary producers[2]. The main producers and other major producers have integrated steel making facilities with plant capacities over 0.5 MT and utilize iron ore and coal/gas for production of steel. The main producers are Tata Steel, SAIL, and RINL, while the other major producers are ESSAR, ISPAT and JVSL (Table 2). The secondary sector is dispersed and consists of: (1) Backward linkage from about 120 sponge iron producers that use iron ore and non-coking coal, providing feedstock for steel producers; (2) Approximately 650 mini blast furnaces, electric arc furnaces, induction furnaces and energy optimizing furnaces that use iron ore, sponge iron and melting scrap to produce steel; and (3) Forward linkage with about 1,200 re-rollers that roll out semis into finished steel products for consumer use. 42% of finished steel production takes place in integrated steel sector and 58% of production in secondary steel sector.

With the change in the business environment where market driven forces became stronger and in view of the integration of global environment concerns with the national concerns, a marked shift towards incorporating energy efficiency and environment protection in the business activities has taken place. Initially focus was on production technology and it was only recently in this process that

1 http://www.ibef.org/industry/steel.aspx
2 http://www.energymanagertraining.com/steel/pdf/industry%20overview%20-%20steel.pdf)

energy efficiency concerns were seeded into the thinking of the respective management. The plants have a wide range of facilities and this is reflected in the energy consumption of the individual plants as well. Overview of the plants is given in Table 2.

Table 2: Capacity, process, production and energy consumption in major steel plants

	Unit	Process	Installed capacity (mtcs*)	Production (mtcs)	SEC (GJ/tcs)
1	TISCO	BF-BOF-CC	3.54	3.434	32.57
2	BSP-SAIL	BF-BOF/THF-IC/CC	3.925	3.743	29.49
3	BSL-SAIL	BF-BOF-CC	4.36	3.353	33.96
4	DSP-SAIL	BF-BOF-CC	1.8	1.5	31.39
5	RSP-SAIL	BF-BOF-CC	1.9	1.19	41.77
6	IISCO-SAIL	BF-OHF-IC	0.38	0.292	39.71
7	VSP-RINL	BF-BOF-CC	2.9	2.576	33.22
8	JSPL	DRI-EAF	0.65	0.4	26
9	JVSL	COREX-BOF-CC	0.8	0.67	

*Tcs: tone of crude steel

Over the years, a number of energy conservation measures have been taken by each plant. Specific energy consumption (SEC) in the integrated steel plants ranges from 29.5 GJ[3]/tcs to 41.8 GJ/tcs. Average SEC of Indian industry (33 GJ/tcs) is slowly approaching that of US industry (26GJ/tcs), however will remain much behind as compared to the most efficient steel making countries are Japan (18 GJ/tcs) and South Korea (19 GJ/tcs).

The JSPL plant which is mostly dependent on the Scrap / DRI-EAF method for steel making, has SEC of only 26 GJ/tcs implying that the use of new routes of steel making with optimal capacities could be used to harness energy for better purposes. The plant uses the DRI off-gases for electricity production. Even though there has been a trend of enhanced energy efficiency and resource efficiency in the India Steel sector, the best is yet to be achieved.

Environmental issues in steel industry are so numerous, complex, and interconnected that an ad hoc approach to problem solving is no longer considered effective. The growing pressure from all stakeholders has forced steel companies to adopt environmental responsibility in all activities. There has been a paradigm shift in the attitude of the steel corporate as it switches over from 'Passive environmental strategies to ‘Proactive environmental strategies’ (Singh et al., 2008). Indian Steel Plants emit 2.5 to 3.0 tonne of CO2 per tonne of steel produced against world average of less than 2 tonne(Prasad, 2007).

Cement:

Driven by a booming real estate sector and increased activity in infrastructure development such as state and national highways, the Indian cement industry has witnessed tremendous growth. Kiln capacity ranges from as low as 10 tonne per day (tpd) to as high as 7500 tpd, however, majority of the production of cement in the country (94%) is by large plants, which are defined as plants having capacity of more than 600 tpd. Presently, there are 130 large plants of varying capacities with total installed capacity of 165 million tonne per annum (MTPA) operating in the country. Of this 73, plants account for 84% of the total manufacturing capacity are of 1 MTPA and above (FICCI, 2007).

Ordinary Portland Cement (OPC) enjoys the major share (56%) of the total cement production in India followed by Portland Pozzolana Cement (PPC) and Portland Slag Cement (PSC). A positive trend towards the increased use of blended cement can be seen with the share of blended cement increasing to 43%. This results in lower CO2 emissions and increasing utilization of waste substances like fly ash, blast furnace slag etc.

3 GJ-Giga Joule (10^9Joule)

The cement industry in India has also made tremendous strides in technological upgrading and assimilation of the latest technology. Currently, 96% of the total capacity uses modern, environment-friendly and energy efficient dry process technology, with only 4% of the capacity based on old wet and semi-dry processes.

Although the newer plants are equipped with the latest state-of-the-art equipment, there is substantial scope for reduction of energy consumption in many of the older plants by adopting various energy conservation measures[4]. The main sources of energy are thermal and electrical energy. Thermal energy is generally obtained from coal, and the electrical energy is obtained either from grid or captive power plants of the individual manufacturing units. Coal availability and quality also affect production. After thermal power plants and the iron and steel sector, the Indian cement industry is the third largest user of coal in the country. In 2003-04, 11,400 million kWh of power was consumed by the Indian cement industry.

Cement manufacturing involves two main areas of environmental concern, namely, dust pollution of the atmosphere and emission of GHG, besides the ecological concern arising from the degradation of mined-out areas. The industry handles millions of tonnes of dry material. Even if 0.1 per cent of this is lost to the atmosphere, it can cause havoc environmentally. Fugitive emissions are therefore a huge problem, compounded by the fact that there is neither an economic incentive nor regulatory pressure to prevent them. Limestone mining has impact on land-use patterns, local water regimes and ambient air quality. There is poor mine management and poor planning for rehabilitation of exhausted land. Mining is one of the reasons for the high environmental impact of the industry. The cement industry does not generate any hazardous or toxic emissions or effluents which are injurious to health.

According to the Department of Industrial Policy and Promotion[5], the industry's achievement in controlling particulate emission has been quite satisfactory. Considerable progress has been made in installing Electrostatic Precipitators (ESPs) and bag houses/fabric filters in various sections of cement plants, especially after the promulgation of the environment legislation in 1981 and 1986. According to The CPCB, most of the new cement plants emit much lower than the stipulated amount.

Total CO2 emissions per tonne of cement (assuming a 0.95 : 1 clinker to cement ratio) is about 0.85 to 1.15 tonne (WBCSD, 2004). The Green Rating Project[6] also found that the emission of carbon dioxide from Indian cement companies is significantly lower than European and American cement companies. "This is an important message to give out to the developed world, where the general feeling is that India is not doing enough to combat global warming," says Chandra Bhushan, head of the GRP and associate director of the Centre for Science and Environment (CSE). For efficient environmental pollution control, Indian cement industry is adopting on-line monitoring by opacity monitors, ESP management systems, Environmental Management Systems (EMS) and ISO-14000, etc. Three Indian cement plants are already accredited with ISO-14000 and a large number are in the process of getting the accreditation.

Chemicals

The Indian chemical industry, 12th largest in production globally, is growing at an average rate of 12.5%. The industry is highly heterogeneous with following major sectors: Petrochemicals, Inorganic Chemicals, Organic Chemicals, Fine and specialties, Bulk Drugs, Agrochemicals, Paints and Dyes, but also highly fragmented and widely dispersed, comprising both small and large-scale units. With the shift in emphasis on product innovation, branch building and environmental friendliness, this industry is increasingly moving towards greater customer orientation. The chemical industry currently produces nearly 70,000 commercial products, ranging from cosmetics and toiletries, to plastics and pesticides. With a special focus on modernization, the Indian government took an active role in promoting and advancing the domestic chemical industry. Chemical industry is one of the highly polluting industries as identified by the Central Pollution Control Board (CPCB).

4 http://www.energymanagertraining.com/cement/pdf/industry%20overview%20-%20Cement.pdf
5 http://siadipp.nic.in/publicat/cement.htm
6 http://www.cseindia.org/programme/industry/green_rating.htm

Textiles
Textiles account for 14 per cent of India's industrial production and around 27 per cent of its export earnings. From growing its own raw material (cotton, jute, silk and wool) to providing value added products to consumers (fabrics and garments), the textile industry covers a wide range of economic activities, including employment generation in both organised and unorganised sectors (MEA, 2008). The sector has shown a 3.7% compounded annual growth rate (CAGR) over the last five years. The structure of the textile industry is extremely complex with the modern, sophisticated and highly mechanised mill sector on the one hand and the handspinning and handweaving (handloom) sector on the other. Between the two falls the small-scale powerloom sector. The latter two are together known as the decentralised sector. India's textiles and apparels industry is estimated to be worth US$49 billion where 39 per cent is accounted by the exports market. The domestic and exports markets in this sector are expected to grow at 6.5 per cent and 12 per cent CAGR respectively. The industry also generates air pollution. Processing of fibres prior to and during spinning and weaving generates dust etc. which degrades working environment in the industry. Dust may cause respiratory diseases in workers. A chronic lung disease, byssinosis is commonly observed among workers exposed to cotton, flax and hemp dust.

Aluminium
The Aluminium industry is highly concentrated, with just five plants accounting for the entire production capacity of 702,000 tonnes per annum. The capacity and production figures for these producers are given below:

	Capacity ('000 tonne)
BALCO	100
HINDALCO	242
INDAL	117
MALCO	25
NALCO	218
Total	702

Bayer-Hall-Heroult technology is used by all producers. Aluminium manufacturing is highly raw material intensive and bauxite and calcined petroleum coke are primary raw materials for this industry. Electricity, coal and furnace oil are primary energy inputs. All plants have their own captive power units for cheaper and un-interrupted power supply. Plants have set internal target of 1 – 2% reduction in specific energy consumption in the next 5 – 8 years. High cost of technology is the main barrier in achieving high energy efficiency.

The major pollutants/wastes generated are (i) red mud (solid waste) from refining of bauxite; (ii) fluoride emission (air pollutant) and spent pot lining (solid waste) from electrolytic stage. The industry also generates CO2 emissions from the electro-chemical production process as well as from the fuel consumption.

Paper
There are, at present, about 515 units engaged in the manufacture of paper and paperboards and newsprint in India. The country is almost self-sufficient in manufacture of most varieties of paper and paperboards. Import, however, is confined only to certain specialty papers. To meet part of its raw material needs the industry has to rely on imported wood pulp and waste paper. Production of paper & paperboard during the year 2002-03 (up to December, 2002) is 2.4 million tonnes. At present about 60.8% of the total production is based on non-wood raw material and 39.2% based on wood.

Pollutants discharged by the paper industry can be divided into four categories: air pollutants, solid wastes, liquid effluent, and noise. Air pollutants from the paper mills are composed of chemical particulates and gases. Particulate emission is controlled to a large extent by improving the performance of recovery furnaces and using venturi scrubbers, electrostatic precipitators and other effective dust collecting devices in the particulate emission passages. Gases emitted are a variable mixture of hydrogen sulphide, methyl mercaptants, dimethyl sulphide and dimethyl disulphide. Sulphur dioxide is also present in the gases in small quantities.

2.1.3 Power Sector

As of February 2008, India has power generation capacity of 141,500 MW (MOP, 2008). 52.5% of the capacity is owned by state, 34% is owned by the central sector and private sector owns the remaining 13.5%. Concerning capacity by resources of generation, coal and natural gas account for respectively about 75300 MW and 14700 MW.

Coal thermal power plants comprise of units varying from 30 MW to 500 MW. Some of the units (smaller size) are as old as more than 40 years. Coal quality is an issue which is deteriorating over years in terms of ash content and calorific value resulting from increasing use of open cast mining. Ash content can be as high as 45 to 50%. This causes operational difficulties in terms of frequent break down and poor boiler performance and pollution hazards.

Coal power plants operated by the Central Government owned National Thermal Power Corporation are better performed with thermal efficiency in the range of 35-37%, whereas, state-owned coal power plants, most of which are old, operate with much lower efficiency of 20-30%. Each percentage increase in efficiency will result into 3% reduction in coal consumption and 3% reduction in CO2/GHG and particulate emissions (Sharma, 2004) .

High ash content coal used in thermal power plants is contributing to enormous problems of environmental degradation through gaseous emissions, particulate matter, fly ash and bottom ash and thereby health hazards. During Stack Emission, SO2 and NOx are released which subsequently get oxidised to sulphate (SO4) and Nitrate (NO3). Indian Power Sector is caught between the pressure of adding new generating capacities to match the rapid growing demand of power to achieve economic and social development and the environmental challenges arising from large scale power generation. The coal based thermal power generation will continue to dominate its role in future also as other energy sources have not yet succeeded to take its place.

The notification of Ministry of Environment and Forests dated 30th June 1998 had stipulated the use of raw or blended or beneficiated coal with an ash content not more than 34% on an annual average basis effective 1st June 2001 (coal with higher than 34% of ash content will be banned from transportation of more than 1000 km of distance). Coal washeries to supply clean coal to power plants more than 1000 km from the coal mines have been made mandatory from June 2001. Coal beneficiation is desirable however, so far supply of washed coal is rare because of limited washery capacity. Sulphur content of Indian coal is generally low, less than 0.2%, therefore, SOx emissions are not considered to be a problem. Since, combustions temperature is low, NOx generation in coal power plants is also considered to be low, leaving particulate emissions as centre of attention. Coal-based generation is also the main contributor to India’s carbon dioxide emissions, linked to changes in global climate.

2.2 REGULATORY AND INSTITUTIONAL ARRANGEMENTS

2.2.1 Air pollution

According to the World Bank report (2007), by any benchmark, India has an extensive environmental management system with a comprehensive set of environmental laws, specific statutory mandates, regulatory instruments, and institutional frameworks to implement and enforce environmental policy objectives. Environmental legislation is on the national list. However, it involves a shared responsibility between the center and the States, with the central government having responsibility for policy and regulatory formulations and the State governments for ensuring implementation and enforcement of national policies and laws. There are over two hundred laws relating to environmental protection. Key national laws for the prevention and control of industrial pollution include the following:

- Water (Prevention and Control of Pollution) Act of 1974
- Water (Prevention and Control of Pollution) Cess Act of 1977, amended in 1991
- Air (Prevention and Control of Pollution) Act of 1977, amended 1987
- Environment (Protection) Act of 1986
- Forest (Conservation) Act of 1980, amended in 1988,
- Public Liability Insurance Act of 1991
- EIA notification, 1994 and 2006
- National Environmental Tribunal Act of 1995
- National Environmental Appellate Authority Act of 1997

The medium-specific legislation (the Air Act and the Water Act) empower the central and state pollution control authorities to enforce emission and effluent standards for industries discharging pollutants into air and water.

The primary institutions responsible for the formulation and enforcement of environmental acts and rules include the Ministry of Environment and Forests (MOEF), the Central Pollution Control Board (CPCB), State Departments of Environment, State Pollution Control Boards (SPCBs) and Municipal Corporations.

The Central Pollution Control Board (CPCB) with the help of academics, research institutions and respective industry develops industry-specific emissions standards which need to be approved by the Ministry of Environment and Forests. Standards are so developed that they are technically feasible and economically viable. Standards are reviewed time to time for tightening further along with the improvement in the availability of better abatement technologies. Respective State Pollution Control Boards (SPCBs) are entrusted with the responsibility of enforcement and monitoring the standards. SPCBs cannot lower ambient environmental quality or emission standards fixed by the central government. It has been argued (Gupta, 1996) that although states cannot compete by lowering environmental standards in order to attract new investment, they can get around this by lax enforcement.

Over the past decade, the courts have stepped in and developed a system of environmental jurisprudence, resulting in significant new policy mandates for both the public and private sectors.

The main environmental management instruments include:

(i) an *Environmental Impact Assessment* (EIA), subject to public hearing and approved by MoEF;
(ii) a *Forestry Clearance,* which requires a project proponent to deposit a compensatory afforestation payment; and
(iii) a *Consent to Establish* (CTE) and *Consent to Operate* (CTO), issued by SPCBs. A CTE is granted after an evaluation of the potential environmental impact and of the design of pollution control installations (OECD, 2007). Conditions for pollution control measures are part of a CTE. Upon verification of compliance with these conditions, a CTO is issued with emission and effluent limits based on industrial sector-specific standards, as well as self-monitoring and reporting schedules. Most small-scale industries operate without any permits.

These instruments are supplemented with economic instruments and other incentives, such as matching grants for the common effluent treatment plants (CETP) or “green awards” introduced by most SPCBs.

Depending upon their pollution potential, the industrial units are classified into three different categories: Red, Orange and Green. The Red category units have maximum pollution potential, the Orange category units have moderate pollution potential and the Green units have the least pollution potential. Further, considering the degree of pollution among the Red units, these are classified into Special Red and Ordinary Red categories. In addition, a few units under the Green category with no pollution potential are classified as Exempted category units. However, these classifications vary across the states.

Most compliance monitoring and enforcement is done by SPCBs. The few direct enforcement actions taken by the CPCB are generally done by the zonal offices. Under the Water Act, the Air Act and the EPA, the pollution control boards have the authority to issue and revoke consents to operate, require self-monitoring and reporting, conduct sampling, inspect facilities, require corrective action and prescribe compliance schedules.

The enforcement powers include emergency measures of disconnecting water or power supply and facility closure, which are widely used in some States. According to the Hazardous Wastes (Management and Handling) Rules of 1989, SPCBs can, with CPCB approval, impose administrative fines for any violation of those rules.

Other sanctions (fines and imprisonment) must be pursued under the criminal authority of the courts. Unlike some other countries where the pollution control authorities are empowered to impose fines depending on the nature and extent of pollution caused, the SPCBs have to approach the judiciary for this purpose. Criminal cases brought by SPCBs are difficult to prosecute, have a low conviction rate (although that varies greatly between the states), and consume precious government resources and time. There are also cases where the polluters, even after conviction, have escaped penalties through legal manoeuvres by highly paid advocates who plead their cases or because of corruption. As a result, regulatory agencies often choose not to pursue sanctions, because the available sanctions are either disproportionate to the environmental infraction or too time-consuming to pursue. Hence, in the absence of credible deterrence, many polluters continue to discharge illegally knowing that there will be no legal consequences. It has been reported that some industries have not installed effluent treatment plants or air pollution control, because they do not believe there is sufficient reason (e.g. deterrent) to comply with environmental standards. In this context, a provision in the new National Environment Policy (2006) that "a judicious mix of civil and criminal processes and sanctions will be employed in the legal regime of enforcement, through a review of the existing legislation" (MoEF, 2006, page 17) is a very encouraging and much needed development, which could greatly improve the credibility of the enforcement regime in the medium to long-term.

Most of the NGOs feel the Government and its machinery are woefully lacking competence and will to deal with the gravity of the situation (CSE, 2006; PSS, 2005). The Pollution Control Boards (PCBs) monitor only Sulphur Dioxide (SO2), Oxides of Nitrogen (NOx), and Suspended Particulate Matter (SPM) – these three parameters are totally insufficient to investigate the reality of the air pollution situation in the nation. The SPCBs only haphazardly monitor the emissions at the industry stacks; there is no system or infrastructure set up to monitor these parameters around industrial estates themselves. The Parliament and the Assembly is presented only the sparse SPCB figures; these bare parameters are insufficient for the legislature to make informed decisions. As a result, neither the Government nor the public has a systematic record of the general ambient air pollution caused by industry.

2.2.2 Climate Change

The Climate Change Division in the Ministry of Environment and Forests is the government lead for the various programmes on Climate Change. The Ministry of Environment and Forests is the nodal Ministry in the Government of India for all multilateral environmental agreements. These include the UN Framework Convention on Climate Change and its Kyoto Protocol. India is a party to the Kyoto Protocol.

In preparation of policies and strategy, the Secretary (E&F) chairs an inter-ministerial and inter-agency Consultative Group for Climate Change Negotiations, which includes key central Ministries and national experts in different fields. Preparatory meetings continue throughout the year (since preparation for each negotiating event starts a year in advance). Apart from this Core Group, there are Sub Groups such as the Political Sub Group on Climate Change and the Modelling Sub Group on Climate Change, which meet at regular intervals.

India submitted its initial National Communication to the UNFCCC in June 2004 well ahead of schedule at the Subsidiary Body Meetings of the UNFCCC in Bonn. The elements of initial National Communication included an inventory of GHG emissions – Carbon Dioxide, Methane and Nitrous Oxide for the base year 1994; the Ministry is preparing the second National Communication.

India is also a partner of the Asia-Pacific Partnership on Clean Development and Climate (APPCDC; commonly referred to as AP6). The Partnership consists of Australia, China, India, the Republic of Korea and the United States of America. The Policy and Implementation Committee (PIC) of the Asia-Pacific Partnership on Clean Development and Climate approved an initial set of projects and activities contained in eight sector-based Action Plans. The Partnership has established public-private Task Forces in eight key sectors: cleaner fossil energy, renewable energy and distributed generation, power generation and transmission, steel, aluminium, cement, coal mining and buildings and appliances.

National Council on Climate Change

The Prime Minister announced this council on 6 June 2007, just prior to the G8 Summit in Heiligendamm, Germany. It comprises government ministers as well as climate experts and industry representatives. The council coordinates national action plans for the assessment, adaptation and mitigation of climate change. It advises the government on proactive measures that can be taken by India to deal with climate change. It facilitates inter-ministerial coordination, and guides policy in relevant areas. Consensus in its first meeting was that India should have a domestic action programme on climate change even while it reiterates that legally binding GHG limitations in any form under multilateral process are unacceptable.

Expert Committee on Climate Change

An expert committee on climate change has been formed by the Ministry of Environment and Forest (MoEF), as recommended by the Union budget in 2007. The nine-member committee will study the impact of anthropogenic climate change on India and identify the measures that we may have to be taken in the future to address the vulnerability to the impacts of anthropogenic climate change. The terms of reference of the committee are:

1. to study the impact of anthropogenic climate change of India,
2. to identify the measures that we may have to take in the future in relation to addressing the vulnerability to anthropogenic climate change impact,
3. any other matter relevant to (1) and (2).

The major issues that need to be addressed by the Expert Committee include:

- high resolution climate change,
- mitigation technologies,
- adaptation strategies.

2.3 MONITORING GHG EMISSIONS AND AIR POLLUTIONS IN LARGE INDUSTRIES AND THE POWER SECTOR

A rising public demand for better environmental quality**,** often driven by the influential urban middle class and backed by the judiciary (as in the famous case of cracking on Delhi's air pollution), is being increasingly matched by voluntary environmental performance obligations from India's large-scale corporate sector and Indian industry asserting a prominent role in the global market (WB, 2007).

The understanding of environmental impacts, their origins, consequences and cost-effective mitigation strategies, while evolving gradually, is still incomplete, and significantly differs across stakeholder groups. All of this further complicates the formulation and delivery of effective environmental management.

2.3.1 Monitoring air pollution

Table 3 presents the emissions of some of the important air pollutants by major industries. Industry is almost the sole emitter of SO_2 emissions. Among different industries, the power sector contributes the largest portion and emissions have increased annually at the rate of 6.8% during 1985 and 2005. Industries share in total TSP emissions has fallen over years, which is resulting from the reduction in emissions from the power sector. Regarding NOx, emissions have increased from power sector over years, while slight increase from cement and steel sector.

Table 3: Air pollutions from industries (in million tonnes)

		SO_2			TSP*			NOx	
Industry	**1985**	**2000**	**2005**	**1985**	**2000**	**2005**	**1985**	**2000**	**2005**
Power	0.723	2.3	2.72	2.6	1.57	0.79	0.38	1.28	1.55
Cement	0.074	0.16	0.21	0.23	0.51	0.54	0.04	0.12	0.15
Steel	0.21	0.31	0.35				0.12	0.21	0.23
Fertilisers	0.125	0.124	0.13						
Other industries	0.438	0.651	0.724	0.37	0.7	0.93	0.28	0.42	0.48
Industry total	1.57	3.545	4.134	3.2	2.78	2.26	0.82	2.03	2.41
All India Total	2.39	4.26	4.8	8.1	9.1	8.7	2.11	4.31	5.02

*Source: Garg et al., 2006, * emissions from steel are included in the other industries*

In order to abate pollution from various sources, MoEF notifies general as well as industry specific emission and effluent standards for various categories of industries under the provisions of the Environmental (Protection) Act (EPA), 1986. Based on development of new pollution control technologies and their feasibility, these standards are periodically reviewed and new ones are notified. The CPCB sets the emissions standards for thermal power plants, with main pollution as particulate matter as sulphur content of Indian coal is low. According to CPCB officials, standards on NOx coming from coal based power plants is not needed as combustion takes place in low temperature, however, in 1999, emissions limit on NOx has been imposed on naphtha and natural gas based power plants. Emission standards for large industries are developed in consensus with the industry itself, taking into account the economic feasibility of the installation of abatement equipment.

Monitoring and inspection are a key function of SPCBs (OECD, 2006). The frequency of on-site visits to verify compliance is determined by the pollution potential (red/orange/green) and size (based on the value of capital investment) of the industry. The CPCB guidance on the frequency of regular inspections is presented in Table 4. However, individual states seem to have differing interpretation of the guidance and do not regard it as binding. For example, red category facilities are supposed to be inspected once a month in Gujarat, once per quarter in Orissa, and once every two years in West Bengal.

Table 4: Minimum Frequency of Inspections: CPCB Guidance

Size of Industry	**Category of Pollution Potential**	**Inspection Frequency**
Large and medium-sized	Red	Once every three months
	Orange	Once a year
	Green	Once in two years
Small scale (capital investment below 10,000 rupees)	Red	Once a year
	Orange	Once in three years
	Green	Once in five years

Source: OECD, 2006

Monitoring procedure varies widely across the states. According to Dr Bischoff of GTZ, some SPCB’s are good and some are weak both in terms of administrative and technical capacity. In-efficient operation of the control devices, irregular monitoring and non-compliance of standards in industries cause concern (Panwar, 2007).

To best deploy resources, some SPCBs are also working to set priorities in keeping with annual plans that prioritize highly polluting sectors, projects or activities. Given the constraints of resource and manpower, the West Bengal Pollution Control Board prioritizes its surveillance over the grossly polluting units instead of monitoring all the units under its consent administration (WBPCB, 2005). The Board has identified 334 grossly polluting units under its regular surveillance. A minimum frequency of monitoring should be laid down as a benchmark to ensure compliance with standards[7]. In addition, given the number of facilities the limited number of SPCB inspectors have to visit, there is tremendous pressure to complete inspections as quickly as possible, which limits their effectiveness and leads to poor detection of violations. Several SPCBs rotate inspectors within the state in order to reduce favouritism, but the need to relocate tends to demoralize staff, who are already overstretched.

In addition to inspections to evaluate compliance, SPCBs conduct inspections in response to complaints and sometimes as part of the consent renewal process. Most inspections are multimedia (covering air, water and waste) and unannounced. There are no standard inspection and sampling procedures prescribed either in the Water Act, Air Act or EPA, or their regulations, and the CPCB and SPCBs have not issued uniform guidelines. As a result, boards develop and apply their own approaches and methods, which is an inefficient way to use limited agency resources. The deficiency of the sampling procedure is quoted as one of the main reasons why courts often rule against the government (OECD, 2006).

[7] http://planningcommission.nic.in/reports/peoreport/cmpdmpeo/volume1/180.pdf

As envisaged in the various Acts, the SPCBs are required to have a technically competent Board of Members, a well-qualified core group of technicians and administrators who are to evaluate, monitor and control pollution at the field level and a network of field offices that facilitates such monitoring and control. Considering the intricate technicalities involved in the functions to be performed by these Boards, it is essential that technical persons possessing scientific knowledge about matters relating to pollution and pollution control hold an upper hand. According to a Planning Commission report, the presence of non-technical people is predominant in the composition of some SPCBs. Given the limited resources, it is desirable that this bias is set right. Non-filling of the sanctioned strength is one of the predominant factors behind the widely varying per unit staff ratios across SPCBs. The absence of any norm for staffing may also have contributed to this. In Andhra Pradesh one technical person has to monitor hundred units where as Kerala and Himachal Pradesh have fourteen and twelve persons respectively for the same task.

Laboratory facilities are vital for monitoring, sampling and analysis activities and are often inadequate. However, some of the SPCBs like WBPCB, claim they have a state-of-the-art laboratory facility. Training of technical staff is another crucial component. Although, most of the SPCBs claim the training of their technical staffs, when the share of training in the total expenditure of State Boards is examined, it becomes clear that the relative importance attached by the SPCBs to this activity is exceedingly low. Many Boards do not have separate divisions for R&D work, nor do they collaborate with any other institution to undertake research. According to the EPA, SPCBs are supposed to develop technologies, but this is rare because of resource crunch. However, development of e-enabled system for environmental compliance in sponge iron plants by WBPCBs is worth of mentioning (Box 3).

Box 3: Environmental compliance in sponge iron plants with e-enabled system

Sponge iron units, one of the most polluting industries, are growing rapidly in India. Besides havoc emission of particulate matter, the process produces toxic gases including carbon monoxide. West Bengal is the first state in India where electrostatic precipitator (ESP) has been installed for rotary kilns in almost all the sponge iron units. Bag filters are present for other areas such as raw material handling, product house, etc. All sponge iron units in West Bengal are coal-based, therefore, potentially more air polluting in nature compared to the gas based units.

Despite having ESP, quite often many of the sponge iron units do not operate their emission control system, primarily in order to cash on electricity causing irreparable environmental damage to the surrounding environment. When the ESP remains non-functional, the units open up the stack cap of the burning chamber to discharge the entire flue gas loaded with particulate matter and results in alarming levels of air pollution. The impacts of air pollution caused by such sponge iron units in urban and rural areas are different in nature. Due to the high population density in the urban areas, the direct impact of such pollution results in severe health hazards in human beings. But in rural areas, the impact is directly on the agricultural crops, livestock and water bodies.

The motives and constraints for not running the pollution control equipment were investigated and some of the possible causes are as follows:

- Paucity of water for running gas-cooling tower, making the electrostatic precipitators (ESPs) dysfunctional;
- Saving on maintenance cost of pollution control equipment;
- Saving on power consumption;
- Lack of skilled manpower for maintenance of ESPs and multi-stage pumps; and
- No direct impact on quality and quantity of production leading to operational ease.

To ensure continuous running of ESPs during plant operation, an interlocking arrangement between the rotary kilns and the ESP has been developed so that if the industry wants to run their rotary kiln without ESP, the feeding system of coal and iron ore through conveyor belt will be stopped immediately and the industry can only restart after necessary compliance of pollution control. The interlocking system can only be reset and opened with a password which would only be known to the WBPCB officials and hence it is very difficult for an industry to bypass the ESP. The salient features of this Environmental Compliance Management & Control System (ECMCS) are given below:

- Capturing data from OPC server on real time identifying non-compliant event;
- Event based log in of non-compliant incidents;
- Withdrawal of permission for running;

- Graphical use interface for administration and report filing;
- Generic configurable system for different plant capacity; and
- Highly secure tamper-proof IT application including reporting mechanism.

The ECMCS is highly secured and configurable for different plant capacities. In addition, the system has rich Graphic User Interfaces, customized reports based on events as well as Time and Instant Messaging triggered by non-compliant events.

The information flow for the ECMCS hinges on monitoring the pre-identified process parameters. The parameters are captured online. In case of non-compliance, logging of parameters is triggered and interlock is actuated to stop the raw material feed to the rotary kiln. The log is used by the WBPCB for any contentions at any time.

The non-compliance report is accessible only to the authorized Pollution Control Board personnel. Suitable mechanism to notify the plant personnel is made available during the non-compliant operations. The violation of interlock is logged in similar fashion Automatic notification to the Pollution Control Board through SMS can be triggered in case of non-compliance.

The ECMCS is the WBPCB.s window to sponge iron plant operations. It eliminates variation in observations due to human factors and ultimately ensure cleaner environment. The system provides:

- Convenient and speedy access to information;
- Transparency in processes and operations; and
- Improved efficiency of auditing services.

Source: WBPCB, 2005, Annual Report, West Bengal Pollution Control Board

Monitoring equipment is generally imported. Suppliers take the responsibility of calibrating the equipments. There are no specified standards for monitoring equipment. CPCB admits there may be faults in the calibration process and equipment maintenance, but they don’t take any measures[8]. CPCB feels India will have the manufacturing capacity within 10 years, thereby eliminating these drawbacks. An interim arrangement would be to have one central institute with authority and capacity for calibration and standardization.

Given resource constraints of SPCBs, self-monitoring and reporting can be an effective tool. According to the national Environmental (Protection) Rules of 1986, each polluting facility must submit an Environmental Statement at the end of each financial year (April through March). The Environmental Statement should include the following information:

- water and raw material consumption;
- air and water pollution discharged by parameter (average daily quantity and concentration as well as percentage of variation from the prescribed limits);
- hazardous waste generation (total quantity from the production process and pollution control installations) and methods of disposal;
- solid waste generation, reuse, recycling, and disposal; and
- pollution abatement measures implemented.

The consents prescribe parameters and respective self-monitoring frequencies, although procedures and requirements across states are not uniform. Lack of reporting or false reporting may lead to criminal or administrative penalties. The existing legal framework, however, does not authorize enforcement actions through the courts based on self-disclosed reports. Rather, government agencies can only pursue legal action on the basis of “legal” samples taken by inspectors who are certified to conduct inspections in accordance with specified procedures. As a result, not using self-reported information is a significant constraint in promoting compliance and enforcement, especially when both financial and human resources are limited for most of the SPCBs. Enforcement mechanism needs improvement, as existing system is inadequate, particularly due to manpower shortage, manipulation by polluters, difficulty in continuous vigilance, etc. As highlighted in the NEP 2006, enforcement efforts are undermined by the lack of credible deterrents: the two key sanctions currently available to the regulator — filing a criminal case against a violating company or issuing an order to shut it down — are either too time consuming to pursue or too extreme to be routinely used.

[8] Personal communication with CPCB officials

Capitalizing on advances in monitoring technology could be another solution. Many SPCBs currently rely on stack testing to monitor the compliance of the majority of industrial units. Continuous Emissions Monitoring (CEM) is an instrument that allows the accumulation of data at a pre-determined time and over a longer period than the stack tests. The CEM can reduce the inspection burden on the regulatory agency by requiring the data to be self reported, or even by directly transmitting the reading results on a stack to a computer at the regulatory agency.

Online access to real-time data facilitates better enforcement as it provides constant vigil. It does not require constant supervision; provides the opportunity for timely corrective actions; delivers measurement discipline; ensures reliability of data, and facilitates quick investigations even for past periods. The values are compared with prescribed standards and violations if any are being displayed. This makes it much more user-friendly. Software can analyze the data as desired, e.g. comparisons with other stations, or on an hourly, eight hourly, monthly or yearly basis. However, CPCB does not maintain any centralized server, where data can be fed into straight from the industry. A pilot project for establishing online transmission of real-time data from Pragati Power Corporation Limited (PPCL), New Delhi has been completed and real-time data are transmitted online to database server at CPCB (CPCB, 2005). The emission data of every 60-minute (customizable to 1 min) is updated and displayed without human supervision or input. Subsequently, based on this demonstration project, the system could be replicated in mega power plants and other major industrial sectors.

Given the difficulties with CPCB/SPCBs staff positions, as well as public concern over possible corruption during on-site inspection, “leap-frogging” to a greater use of the CEM technology seems a particularly attractive option in India, and is currently being promoted by the CPCB. However, switching to CEM on a large scale would be expensive and needs to be phased-in. In addition, a strong quality assurance plan, along with the capacity to implement it well, is needed, which would include calibration checks and adjustments, record-keeping and reporting, and procedures for conducting periodic performance tests.

CREP has one component on requirement on the installation of continuous monitoring. Cement Manufacturing Association (CMA) has been asking for 3-4 years for its implementation. They feel equipment quality is not good, although it is improving, that makes cement plants to be cautious about adoption continuous monitoring. A survey showed 35 out of 85 companies have complained about the quality of the equipment, which sometimes cause erroneous recordings. CMA is negotiating with CPCB to install an opacity meter by 2006-08 as a first step, CPCB didn’t agree on that. 20% of the Integrated Steel Plants have online monitoring system and ambient monitoring station within the plants.

While sponge iron units are monitored there are no standards. CPCB has worked on standards which will be effective soon. Standards for PM for power plants in sensitive areas is 50 mg/Nm^3 and for remaining areas 150 mg/Nm^3. CPCB thinks most of the new plants comply with 50 mg/Nm^3 and they are equipped with online monitoring system. Only about 10% of power plants, which are very small in size (and therefore contribute only insignificantly to total capacity) do not have an online monitoring system. These power plants are due to be phased out by 2010. Although the remaining power plants have online monitoring systems, there is no centralized system where data are reported. Data are monitored through manual inspection. For dioxins and fluoride, sample collection is done in India and then they are sent to Germany for testing because India does not have testing facilities.

The Environment Laboratory of RDCIS of SAIL primarily undertakes various time bound projects aimed at providing innovative and cost effective solutions to typical pollution related technological problems faced by SAIL steel plants. RDCIS also undertakes monitoring work for specific pollutants. Being a recognized laboratory of Central Pollution Control Board (CPCB), it has also offered monitoring and testing services to various agencies outside SAIL steel plants with the aim of generating reliable data for better management of environmental pollution (from Ministry of Steel website).

Although SMEs are not specifically within the scope of this report, communications with several types of stakeholders make it clear that the situation with small and medium-sized enterprises (SMEs) is much worse. According to the MOEF, SMEs account for 40 percent of industrial production, employ limited pollution control technologies and are responsible for an estimated 70 percent of the total industrial pollution load nationwide (OECD, 2006). While the total number of inspections conducted by different SPCBs is impressive (for example, in Andhra Pradesh, 24,565 inspections were carried out over the last three years), most SMEs are inspected very rarely or never at all. Solving the pollution problem of these industries is complex for various reasons which include techno-economic problem, space constraints, lack of awareness etc (WBPCB, 2004). Their problems can be solved by a combination of pressure and persuasion, continuous negotiations with the associations of such industries and also arranging/facilitating financial assistance for taking necessary pollution control measures.

There are a growing number of voluntary incentives by the industry to demonstrate environmental stewardship to company shareholders, consumers, communities, consumers, and other key stakeholders. Many companies in India and internationally have implemented the Environmental Management Systems (EMS), such as ISO 14001, resulting in both economic and environmental benefits from improved performance and production efficiency. This is compelling many export-oriented firms, such as chemical manufacturing facilities in Gujarat or pharmaceuticals firms in Andhra Pradesh, to adopt voluntary initiatives to demonstrate corporate responsibility as well as sustained environmental performance beyond strict regulatory compliance. For example, the numerous export-oriented industries in Naroda are reportedly taking steps to improve their environmental compliance primarily driven by the export demand from their clients abroad.

There are instances where successful voluntary agreements made between the industry and government to gradually improve environmental performance beyond compliance requirements have later been made mandatory and incorporated into law. One example is the agreement with the cement industries to improve their emission levels to 50 μg/Nm^3 from 100 μg/Nm^3 which is set to become a legal requirement in 2006. Some SPCBs have started requesting an ISO 14001 certificate from the 17 most polluting categories of industries before the renewal of their consents/authorizations. While this has reportedly led to better compliance, industry stakeholders consulted during the study mentioned that turning a voluntary agreement with individual companies into a mandatory requirement for the entire sector can be a disincentive for companies to explore voluntary initiatives in the future.

Area-Based Environmental Management Programs approach to environmental regulation has been tried in India since 1991 through different CPCB and SPCB programs. For example, the CPCB and concerned SPCBs identified 24 “critically polluted/problem areas”, action plans for which (including compliance monitoring measures) have been developed and are in various stages of implementation. While area based programs have an advantage of focusing regulatory and compliance monitoring efforts of the concerned SPCBs, they so far have had mixed success in India, mostly due to the lack of coordination of efforts targeting industry, municipal, mobile, and non-point pollution sources.

2.3.2 Monitoring GHG emissions

The industrial sector, being energy intensive, is also large source of GHG emissions (mainly CO2). In addition, CO2 is generated from the manufacturing process of some industries, e.g. iron and steel, cement, aluminium etc. Garg et.al. (2007) have estimated trends in sector-wise CO2 emissions from different industries. Table 5 presents the CO2 emissions for industries. Growth in CO2 emissions varies across different industries. Emissions from cement and steel have grown at faster rate than the industrial total of 4.6% per annum between 1985 and 2005.

Table 5: CO2 emissions in Million tonnes

	1985	2000	2005	CAGR (%)
Power	146	517	638	7.65
Cement	28	77	98	6.46
Steel	26	92	103	7.13
Fertilisers	20	23	24	0.92
Other industries	62	100	109	2.86
Industrial total	136	292	334	4.59
All India Total	440	1032	1229	5.27

Source: Garg, et al., 2006

GHG emissions are not regulated; industries do not need to report GHG emissions or comply with any standards and therefore industries do not monitor GHG. However, some initiatives in this front are taken recently, primarily from international interests or initiatives from some national NGOs. Some of these initiatives include the Carbon Disclosure Project (CDP; please see Box 4), the Green Rating project by CSE, different initiatives by the World Business Council for Sustainable Development (WBCSD). In addition, Steel Authority of India Ltd., the largest public sector steel manufacturing company, is working with International Iron and Steel Institute (IISI) in Brussels on accounting and reporting GHG emissions from the steel industry to homogenise the accounting and reporting process internationally and develop various sustainability indicators which include CO2 intensity also. To some extent, environmental management is becoming part of the corporate strategy at least for the big industrial houses (Please see Box 5). Although at its nascent stage, corporate environment reporting is emerging as a tool.

Box 4: The carbon Disclosure project (CDP)

CDP was established in 2000 and provides a secretariat for institutional investors to request information on climate change from the companies in which they invest (CDP, 2007). In 2007, CDP expanded to India in collaboration with the World Wide Fund for Nature –India (WWF-India) and the Confederation of the Indian Industry (CII) ITC Centre of Excellence for Sustainable Development (CESD). This project targeted 110 of India's largest companies including 51 from high impact sectors, by including then in the 2007 CDP information request to solicit information on:

- Opportunities and risks from climate change and strategies adopted to respond to this,
- Direct and indirect greenhouse gas (GHG) emissions
- Emission reduction strategies
- Corporate-level climate change management and governance

39 companies from 17 sectors (about 35%), responded which include 18 companies from high impact sectors. 15 (38%) companies reported Scope 1(direct CO2 emissions from fossil fuel burning) GHG emissions data. The number of companies that reported Scope 2 (CO2 from imported sources) and Scope 3 (from other sources) GHG emissions data was lower 23% and 18% respectively. The majority of the companies that reported GHG emissions data have used the GHG protocol methodology. Non-availability of information and difficulty in obtaining the same were cited as the key reasons for not providing the GHG emissions data by most companies. Disclosure may be expected to improve following increased familiarity with measurement tools and protocols.

26% of the responding companies provided details of emissions intensity. GHG emission per unit of output or input was the most common emission intensity ratio considered by the responding companies. Two companies reported emission intensity as a percentage of base year emissions.
Emissions trading opportunities are being considered by 46% of the responding companies. 38% of the responding companies have allocated board or upper management level responsibilities for climate change issues. This year, CII has intention to increase the number of companies substantially.

Box 5: A case study on ITC

ITC presents an interesting case of a company responding in numerous ways to make their systems and processes environment-friendly, energy-efficient and responsive to climate change. Various initiatives taken by ITC include the following:

ITC (tobacco, hotels, paper, food) has charted out a quiet but ambitious move to become the only corporation on earth to achieve triple green rating –it is already water positive, and is now moving to become both carbon positive and have zero solid waste.

In all its hotels, high-tech water treatment plants (that cost US$ 100,000 each) ensure that the water used in the rooms, the kitchen and by the laundry department is recycled back for use in the hotel gardens, in the cooling towers for the ACs, etc.

It has succeeded in registering as many as seven CDM projects accounting for one million CERs.

The carbon sequestered during 2003-04 at 174,000 tonnes, offsetting carbon dioxide to the tune of 636,000 [??] tonnes. As per current pulp requirements, the company needs only 4000 ha of plantations annually, but is actually covering more than 10000 ha, delivering bumper yields.

For more please see (CII, 2008)

In this context it is worth mentioning the Green Rating Project (GRP) of the Centre for Science and Environment (CSE), Delhi, which is an effort to rate industrial units within a specific sector on the basis of their environment friendliness. Green Rating Project is an attempt to present a market-oriented framework by which the environmental impacts of industrialisation can be measured and monitored. This is a reputational incentive programme, which rates the environmental performance of companies within a specific sector. The results of this research are then disseminated to a wide audience, including investors, consumers, media and financial institutions, both within India and abroad. The project is also intends to aid in better regulation of industrial pollution by regulatory authorities and, in better formulation of policies by the government leading to sustainable development of Indian industries.

For assessing actual environmental performance, CSE uses the broader Life Cycle Analysis (LCA) instead of the more limited Environmental Impact Assessment or environment audit made by official agencies. This is a highly technical process and has no precedence in India. So, the project is not only building a database of India's industrial sectors, but also setting-up the process and methodology for environmental benchmarking of the industrial sector and companies within it.

CSE's initial focus is on multinational companies and major Indian companies on the stock market as they are conscious about their public image, especially those that are trying to raise funds abroad. Also they are the ones that have the means available to obtain world class technology. Large industries are generally trend-setters and as industry leaders, they can set the standards for other companies to follow. Since its inception in 1995, GRP has covered pulp and paper, cement, automobiles, and chloro-alkali industries. According to Green Rating Project's assessment, the Indian cement sector is (after Japan) the second most energy-efficient cement sector in the world. However, although India has some of the best plants in the world in terms of energy performance, other cement plants have substantial potential for reducing energy consumption.

Cement production is a major source of carbon dioxide emissions: five percent of the global total. World Resource Institute (WRI), along with the World Business Council for Sustainable Development (WBCSD), introduced the Cement Sustainability Initiative (CSI) that builds on the ISO-recognized GHG Protocol. The Climate Protection Task Force (TF1) aims to improve the quality of public information available, particularly for companies working to manage emissions accounting, emissions limitations, and emissions trading. The Task Force initially created a CO_2 Accounting Protocol in cooperation with the World Resources Institute. (See www.wbcsdcement.org/pdf/co2-protocol.pdf).

In June 2005, the Task Force produced a protocol for measuring and reporting CO_2 emissions that is consistent with the WRI/WBCSD Greenhouse Gas (GHG) Protocol. This protocol is intended as a tool for cement companies worldwide. It provides a harmonized methodology for calculating CO_2 emissions, with a view to reporting these emissions for various purposes. It addresses all direct and the main indirect sources of CO_2 emissions related to the cement manufacturing process in absolute as well as specific or unit-based terms. Four plants/companies in India, ACC, Ambuja, Grasim and Sree cement plants are member of CSI.

Most Indian CDM projects are in the renewable energy sector, while the number of CDM projects in thermal power and large industries is relatively low. However, this picture may change. For example, SAIL (steel industry) has identified 70 CDM projects, which are being further developed by consultants. With one of the largest number of CDM projects in the World, India has well-experienced consultants and institutions in the monitoring methodologies related to CDM. These are generally activity-based, i.e. emissions are calculated from fuel consumption, and GHGs are seldom monitored directly.

GHG Monitoring in power sector

The power sector in India is the single largest source of CO_2 emissions, contributing about 50% of the total emissions in the country (Garg et al., 2006). According to Garg et al. (2006), during 1985-2005, emissions from this sector have grown at the rate of 7.7% annually.

Factory level monitoring of GHG emissions are not in place. However, monitoring and reporting of CO2 emissions from the power plants are straight forward. All thermal power plants report the actual fuel consumption along with their quality (e.g. heat and ash content for coal) to the Central Electricity Authority (CEA). Of late, CEA brings out the plant wise CO_2 emissions which are currently used for CDM purpose (for the calculation of grid co-efficient used for baseline). It is primarily based on calculation, taking into account fossil fuels (coal, oil and gas) consumed in the power plants, associated calorific values and an average oxidation factor. These figures are updated on regular basis based on their actual values. Member, Planning of Central Electricity Authority feels the methodology should be harmonized internationally. For example, power plants in India use net calorific value (or low heat value) whereas, high heat value (or gross calorific value) is used for any thermal calculation in USA. This may cause 2-3% difference in even emissions factor and hence overall emissions calculations.

In India’s Initial national Communication to UNFCCC the IPCC (1996 Guidelines) Tier-I, II and III approaches were used to estimate GHG inventories,. The choice of the approach for a sector depended on the quality and availability of activity data and emission coefficient as required by each approach. First National Communication has made the estimation of indigenous emission coefficients in several key sectors through direct field measurements using rigorous scientific methodologies which have contributed to the accuracy and reliability of the GHG budget estimates. However, considerable uncertainties thus would exist in the present emission estimates of GHGs from various sectors. It attempted to estimate actual emission factors for power plants, cement plants and steel plant, through actual stack level measurements, however, sample size was too low to generate some reliable estimates. For example, measurement was taken in only one steel plant and two-three power plants. It leaves scope for improvement in large number of sectors, primarily in industries, such as steel, chemicals etc. In its second communication, some of them may be addressed.

2.4 SOME SCHEMES THAT CAN CONTRIBUTE TOWARDS IMPROVING MONITORING CAPACITY

Charter on Corporate Responsibility for Environment Protection (CREP)

The Ministry of Environment and Forests and the industrial sector have entered into a partnership on voluntary pollution control by releasing a charter on Corporate Responsibility for Environmental Protection (CREP). The CREP comprises a set of 153 guidelines that would assist the corporate sector in streamlining environmental management. It covers 17 highly polluting industries, which include aluminium, cement, chlor-alkali, copper, dyes and dye intermediates, fertilizer, iron and steel, pesticide, petrochemical, pharmaceutical, paper and pulp, sugar and zinc segments, tanneries, thermal power plants, distilleries, and oil refineries. They total about 2098 units.

The action points listed in the Charter are addressed to corporate bodies as well as regulatory agencies. Thus, the Charter is a commitment for partnership and participatory action of the concerned stakeholders. The Charter is also a road map for progressive improvement in environmental management systems and, it is not necessarily limited to compliance of end-of-the-pipe effluent and emission standards. In a number of industrial sectors, the targets set in the Charter are ahead of effluent and emission standards.

The environment charter marks a shift from regulatory enforcement of pollution control norms to voluntary compliance by the industry to significantly enhance the quality of the environment. For effective implementation of the Charter, eight task forces comprising of experts and members from institutions and industry associations have been constituted. These task forces are meeting regularly to monitor and to provide guidance to the industries for adopting necessary pollution abatement measures. Monitoring becomes part of environmental management. National Task Force on cement industry has recommended for installation of continuous monitoring system in cement industry[9]. Other industries like zinc, copper have agreed upon installation of continuous SO2 monitoring system[10].

Industrial Pollution Abatement through Preventive Strategies

CPCB has introduced this Scheme as an amalgamation of the three on-going sub-scheme viz. (i) Environmental Audit; (ii) Adoption of Clean Technologies in small Scale Industries, and (iii) Environmental Statistics and Mapping (CPCB, 2007). Environmental auditing or development of environmental statistics explicitly or implicitly involve some measuring and monitoring of pollutions.

Technical assistance from USAID and other donors helped to prepare the ground for the spread of Environmental Management Systems leading to ISO 14000 in India. Today, an increasing number of firms in selected industrial sectors (textiles, pulp and paper, pharmaceutical, automobile, thermal power, steel and cement) meet these standards. Acquiring this certification also involve accounting and reporting of emissions.

2.5 CONCLUSIONS

Despite the regulatory and institutional frameworks that are in place, monitoring GHGs and other air pollutants pose great challenges. While most of the problems are related to implementation; better laboratory facilities, capacity for sampling, experiment and analyses would improve the quality of monitoring and standards specification. Given the size of the country and to cope with the growth of the complex industries such as steel, chemicals etc, increasing the number of laboratories will also be necessary to make the facilities easily accessible. R&D activities need to be strengthened where international assistance may be helpful in the forms of financial and technical cooperation.

Calibration and maintenance of monitoring equipments are entrusted with the foreign suppliers as the country does not have facilities to manufacture these equipments. There are no specified standards for monitoring equipments. CPCB admits there may be fault in calibrating process and also maintaining the equipments, but they don’t take any measures. Given the country has a large market, manufacturing of automatic monitoring system locally under joint venture would help to develop local technical capacity and knowledge to remove the problems of maintenance and calibration. Additional measure would be to establish a central institute with authority and capacity for calibration and standardization.

Supply of automatic monitoring system based at subsidized rate may promote self-monitoring thus reducing the pressure on SPSBs which are in shortage of technical staffs and financial resources. Instrument like CREP, voluntary initiatives, rating system for most important industrial polluters based on self-reported and inspection data may work out to be cost effective solutions.

A frequent (and valid) argument from the industrial community is that new investments in large industrial projects bring modern and clean technologies, and big companies, particularly those with global market outreach, increasingly adhere to sound management practices. In reality, the impact of industrial growth is more nuanced and complex. An estimated 70 percent of the total industrial

[9] http://cpcbenvis.nic.in/highlights/highlight2004/highlight2004ch5.htm

[10] http://74.125.39.104/search?q=cache:QcANbj5l1g0J:cpcbenvis.nic.in/highlights/highlight2003/highlight2003ch9.htm+CREP+and+iron+and+steel+and+india+and+monitoring+system&hl=en&ct=clnk&cd=2

pollution load is attributed to small and medium enterprises (SMEs) many of which, especially small-scale units, continue to use obsolete technologies with no or primitive pollution control methods. With about 40 percent of the total value of industrial production and over 4.5 million units across the country, the SME is a major engine for growth, employment and poverty reduction, raising a dilemma of balancing economic and environmental objectives. Given their diversity in terms of types, scales, financial and technical capacity etc, almost all stakeholders we communicated feel SMEs poses much bigger challenge in terms of pollution management. Although, GTZ, Indo-Canadian Environment Facility are engaged in this area, however, given the size of the problem there is substantial room for further international involvement and assistance.

Concerning GHGs, National Communication has become a regular affair. However, considerable uncertainties exist in the present emission estimates of GHGs from various sectors, in particular in industries. Scientific measurements are needed to improve the quality of emissions factors, where international cooperation in the forms of technical and financial aids may be desirable.

2.6 REFERENCES

ADB, 2005, Strengthening environmental management at the state level (cluster), Component E: Strengthening environmental management of West Bengal State Pollution Control Board, Final Report, Volume V, Air Quality Management,

CII, 2008, Building a Low-Carbon Indian Economy, Energy Department, Confederation of Indian Industry, New Delhi.

CPCB, 2005, http://cpcbenvis.nic.in/highlights/Highlights05/ch-13.htm

CSE, 2006, The Leapfrog Factor, Clearing the air in Asian cities, Centre for Science and Environment, New Delhi.

FICCI, 2007, FICCI Climate Change Task Force Report, Federation of Indian Chambers of Commerce and Industries, New Delhi.

Garg., A., Shukla P.R., and Kapshe M., (2006)., The sectoral trends of multigas emissions inventory of India, Atmospheric Environment 40 (2006) 4608–4620.

Gupta, Shreekant (1996). "Environmental Policy and Federalism in India." *National Institute of Public Finance and Policy.* Mimeo.

MEA, 2008, http://mea.gov.in/indiapublication/TextilesIndustry.htm

MOEF, 2006, Annual Report-2006/07, Ministry of Environment and Forests, Government of India, New Delhi.

MOP. 2008, Ministry of Power, (http://powermin.nic.in/indian_electricity_scenario/power_sector_at_a_glance.htm

OECD, 2006., Environmental Compliance and Enforcement in India: Rapid Assessment, http://www.oecd.org/dataoecd/39/27/37838061.pdf

Panwar., T.S., Environmental issues and policies in India, INDRU kick-off meeting, 5th Dec. 2007, IIC New Delhi

Prasad., S.B., Climate change and steel sector, IPCC Working Group III'S Dissemination Workshop on Fourth Assessment Report, October 11-12, 2007 Kolkata.

PSS, 2005, PSS finds Carcinogens in ambient air, Press Release, Paryavaran Suraksha Samiti, Vadodara.

Sharma., S.C.D., (2004) Coal-fired Power Plant Heat Rate and Efficiency Improvement in India, APEC Workshop on Options to Reduce CO2 Emissions, February 16, 2004, http://www.iea.org/dbtw-wpd/Textbase/work/2004/zets/apec/presentations/sharma.pdf

Singh R.K., Murty H.R., Gupta S.K., and Dikshit A.K., Development and implementation of environmental strategies for steel industry, International Journal of Environmental Technology and Management, Volume 8 - Issue 1 – 2008).

WB 1997, Inspections and emissions in India-puzzling survey evidence about industrial polluction, Policy research working paper 1810, Development Research Group, The World Bank.

WB, 2007, India:Strengthening Institutions for Sustainable Growth -Country Environmental Analysis, South Asia Environment and Social Development Unit, South Asia Region, The World Bank.

WBCSD, 2004, The Indian cement industry – a perspective of environment friendliness, http://www.wbcsd.org/web/projects/cement/tf5/cement-india.pdf

WBPCB, 2005, Annual report 2005/06, West Bengal Pollution Control Board, Kolkata.

WBPCB, 2008, (http://www.wbpcb.gov.in/html/activities.shtml#IPC)

3. INDIAN CAPACITY TO MONITOR ATMOSPHERIC CONCENTRATIONS OF AIR POLLUTION

3.1 BACKGROUND INFORMATION

Clean air provides both health and economic benefits. In the short term, clean air provides immediate quality of life and health improvements. In the longer term, clean air reduces health care costs, increases longevity, helps foster beneficial business development, and can aid in improving the overall standard of living (PREIS, 2004).

Depending on the process of formation, the air pollutants are generally classified as primary and secondary pollutants. The primary air pollutants are generated directly from the sources, whereas secondary air pollutants are generated from the primary pollutants by complex chemical reactions in presence of ultra –violet radiation involving free radical formation (WBPCB, 2004).

Primary air pollutants

i. Suspended Particulate Matter (SPM)
ii. Respirable Suspended Particulate Matter (RSPM)
iii. Sulphur Oxides (SOx)
iv. Nitrogen Oxides (NOx)
v. Carbon Monoxides
vi. Hydrocarbons of different types
    1. Benzene, toluene, xylene
    2. Poly-Aromatic Hydro Carbons
    3. Benzene soluble aromatic fractions
vii. Toxic materials like lead, cadmium etc.

Secondary pollutants

Ozone (O_3)
Aldehydes
Peroxy Acetyl Nitrate (PAN)
Peroxy Benzile Nitrate (PBN)

The air quality of a region depends on the concentrations of the above mentioned pollutants present in ambient air. In order to manage air quality of an area, three key areas need to be studied scrupulously:

- identification of the possible sources that emit the air pollutants,
- assessment of contribution of air pollution from various sources, and
- monitoring of pollutant concentrations in the air of the surrounding area.

3.2 AIR QUALITY MONITORING

Air quality has been monitored in India since 1967. The Central Pollution Control Board, the central regulatory authority, is executing a nation-wide National Air Quality Monitoring Programme (NAMP). Over the years, the monitoring stations have increased in number and the capabilities for monitoring have improved through various capacity building initiatives supported by the Government and also through the bilateral cooperation (e.g. Indo-German collaboration)[11]. The network consist of 332 operating stations covering 121 cities/towns in 25 States and 4 Union Territories of the country (CPCB, 2007). The objectives of the NAMP are to determine status and trends of ambient air quality; to ascertain whether the prescribed ambient air quality standards are violated; to identify non-attainment cities; to obtain the knowledge and understanding necessary for developing preventive and corrective measures; to understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

[11] http://www.cleanairnet.org/caiasia/1412/articles-70581_v43.pdf

Table 1: National air quality standards specified by CPCB					
Pollutants	**Unit**		**Industrial areas**	**Residential areas**	**Sensitive areas**
SO_2	µg/m3	Annual average 24-hours average	80 120	60 80	15 30
NOx	µg/m3	Annual average 24-hours average	80 120	60 80	15 30
SPM	µg/m3	Annual average 24-hours average	360 500	140 200	70 100
RSPM	µg/m3	Annual average 24-hours average	120 150	60 100	50 75
Lead	µg/m3	Annual average 24-hours average	1.0 1.5	0.75 1.0	0.5 0.75
Ammonia	Mg/m3	Annual average 24-hours average	0.1 0.4	0.1 0.4	0.1 0.4
CO	Mg/m3	8-hours 1-hour	5 10	2 4	1 2

Source: *http://www.cpcb.nic.in/Environmental%20Standards/default_Environment_standards.html*

The Central Pollution Control Board (CPCB), as the apex body, has laid down national standards on ambient air quality and source specific emission standards for implementation at the local levels through the concerned officials of the State Pollution Control Boards (SPCBs) (Table 1). Under NAMP, four air pollutants viz., Sulphur Dioxide (SO2), Oxides of Nitrogen as NO_2 and Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM/PM10[12]), have been identified for regular monitoring at all the locations. PAHs, NH_3, H_2S are monitored in few cities. BTX and Ozone monitoring is carried out in Delhi and some other major cities.

The main focus of air quality monitoring is urban areas, in particular large metros, like Delhi, Mumbai etc where rapidly increasing vehicle population makes it difficult to keep control on urban air quality. The monitoring of meteorological parameters such as wind speed and direction, relative humidity and temperature have been integrated with the monitoring of air quality. The monitoring of pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with frequency of twice a week. The monitoring is being carried out with the help of Central Pollution Control Board, Zonal Office, State Pollution Control Boards, Pollution Control Committees, and the National Environmental Engineering Research Institute (NEERI), Nagpur. CPCB co-ordinates with these agencies to ensure the uniformity, consistency of air quality data and provides technical and financial support to them for operating the monitoring station. Since, NAMP is being operated through various monitoring agencies and large number of personnel and equipment are involved in the sampling, chemical analyses, data reporting etc. it increases the probability of variation and personnel biases reflecting in the data. Hence, it is pertinent to mention that these data be treated as indicative rather than absolute. Some NGOs like Centre for Science and Environment (CSE), The Energy Research Institute (TERI) monitor air quality in certain locations[13].

In addition to manual air quality monitoring network, continuous monitoring systems have also been established at various places including Delhi, which provide instantaneous information on pollution levels of different pollutants. The Central Pollution Control Board operates continuous ambient air quality monitoring (CAAQM) at three fixed locations in Delhi and one mobile van. Various pollutants viz. SO_2, NO_2, CO, RSPM, PM2.5, Benzene, Toluene, Xylene, Ozone, etc. are monitored. In order to

12 Respirable particulate matter (RSPM) or PM10 are particles having a diameter of less than 10 micron
13 http://www.adb.org/Documents/Events/2004/SASEC/3rd-environment-mtg/langgons1.pdf

make these data available to public on real-time basis, a network for online real-time data transmission has been established at CPCB. Air quality data could be accessed through CPCB's website (http://www.cpcb.nic.in). Air quality data is being updated on the website every 15 minutes. Besides, analyzed data (short as well as long-term averages) and comparison with prescribed ambient air quality standards, etc. could also be searched, viewed, downloaded for further interpretation or analysis. The values compared with prescribed standards and violations, if any, are also being displayed. Software can also analyze the data as desired normally like comparisons with other stations, hourly, eight hourly, monthly, yearly data analysis etc.

In order to expand its monitoring network with sophisticated monitoring equipment and also to monitor some toxic air pollutants, some of the states also have installed continuous monitoring szstem. For example, the WBPCB during 2002 installed automatic air quality monitoring stations at five locations in the state. Besides monitoring of conventional parameters, these equipments are capable of monitoring special air quality parameters like CO, O_3, and hydrocarbons. The said monitors are capable of collecting a wide variety of analysed data for air pollutants and meteorological parameters, which through a telephone line and modem are transmitted to the central computer system of the Board. Automatic Air Quality Monitoring Stations have also been set up in Hyderabad and Bangalore for continuous air quality monitoring (CPCB, 2007).

According to a CSE report, CPCB should evaluate if the standards should be lowered further to achieve the new WHO guidelines for particulate matter and other pollutants. India has not yet considered how the ambient air quality standards setting process can be made dynamic and responsive to changes in air quality[14]. The current focus on only a few big polluted cities and also a set of limited number of pollutants are certainly not adequate to address the public health challenge of air pollution. For example, fine particles PM2.5 are responsible for causing the greatest harm to human health. However, currently, there is no standard imposed on it. Setting standards and regular monitoring of pollutants like PM2.5, O3 are needed. Clearly, city based action-planning along with periodic assessment and reporting on progress should become the norm. Special studies to be carried out periodically could include VOC's, PAH's, heavy metals, etc.[15]

According to a TERI report (2001), the air quality monitoring network is fairly extensive. While its performance has gradually improved over the years, important gaps remain:

- Many stations are not operational;
- The target number of sampling days required 104 days a year which is rarely met even at operational stations;
- The data are not comprehensively and statistically analysed for temporal and spatial trends;
- Many stations no longer represent the type of site (such as urban "hot-spots"; areas affected by vehicle and industrial emissions; city centre pedestrian precincts and residential areas representative of population exposure; parks and suburban areas) they were originally selected for because of the changes in land use pattern, habitation and commercial activities. There is a need to relocate some stations;
- There are significant delays in reporting the data (typically one to two years);
- Based on the data collected to date, the pollutant of concern in cities in India is particulate matter. Its concentrations have been shown to far exceed the national ambient air quality standards in city after city;
- The pollutants being monitored should be reconsidered. In particular, instead of monitoring total suspended particles (TSP), which are now widely acknowledged not to be important from the point of view of public health impact, smaller particles such as PM10 (particles smaller than 10 microns) or even PM2.5 (particles smaller than 2.5 microns) should be monitored regularly;
- Given limited financial resources, rather than expand the monitoring programme by establishing new stations, the National Ambient Air Quality Monitoring Programme (NAMP) should focus on improving data collection and analysis at the existing stations (specially focusing on training, ensuring that sampling frequency be met, ensuring regular calibration of flow rates and, in the case of gaseous pollutants, strictly adhering to prescribed operating procedures);

[14] http://www.cseindia.org/campaign/apc/pdf/cityaction.pdf
[15] http://www.adb.org/Documents/Events/2004/SASEC/3rd-environment-mtg/langgons1.pdf

- In addition to the regular monitoring, data collection for special studies (such as source apportionment) and surveys could be carried out by the Central Pollution Control Board (CPCB) and National Environmental Engineering Research Institute (NEERI) two organisations involved in regular air quality monitoring in India in collaboration with other research organisations.

CPCB admits that the present Indian air quality monitoring system is limited in its scope and accuracy. Information transferred to CPCB is scarce, and sometimes unreliable. CPCB feels the need to modernize and amplify it according to international standards [16]. Internationally, the use of automatic monitoring stations is widely recommended because of its accuracy, reliability and the possibility to develop alert systems in the case of pollution peaks. Manual stations are mostly limited to some specific pollution parameters for which automatic monitoring are not yet feasible (some heavy metals, PAH, some particles). However, automatic monitoring is an expensive method of air quality monitoring. In order to ensure that the data produced are accurate and reliable, strict maintenance, operational and quality assurance/control procedures are often required. International assistance can be useful.

According to CPCB, the Indian air quality monitoring system should be modernized to address the following problems:

- Measure air quality in representative areas and representative time periods to inform and protect the Indian population.
- Measure continuously air pollution in major Indian cities and industrial areas and compare mean and peak values with air quality standards.
- Develop alert system in case of high pollution episodes.
- Develop air quality forecast systems and procedures.
- Standardize at the national level the monitoring and quality control procedures. Set up a valid and quality controlled local and central air quality database.
- Set up a standardized data transfer and data processing system that enables a free flow of information between cities, central government and eventually the public.
- Define clearly the responsibilities of the Central Government, States, Municipalities and industries, and organize transfer of information between these structures
- Organize the operation and maintenance procedures in order to insure good working conditions to the systems, and promote a funding scheme.

The Central Pollution Control Board (CPCB) has initiated a French sponsored study on modernization of National Ambient Air Quality Monitoring Stations & Networking in India and integrating private participation in air quality monitoring.

To find out the workable solution for India, a fact-finding mission visit was scheduled in 2004 for the identified countries Germany, France, U.K., Malaysia and Thailand having various models of management – Public Private partnerships. The proposed Fact finding mission will help to integrate effective private participation & modernize our Ambient Air Quality Monitoring Network. The project being conceived based on the findings of this mission are as below:

I. Proposal for Networking of Continuous Ambient Air Quality Monitoring Station in identified 10 cities namely Mumbai, Kolkatta, Chennai, Delhi, Hyderabad, Banglore, Ahmedabad, Vadodara, Kochi and Vishakhapattnam. It is proposed to develop three level/data management & transfer. (Level 1: National, Level 2:State and Level 3:City). First priority towards developing such Automatic Air Quality Monitoring Network shall be given to following identified metro cities & cities where Continuous Ambient Air Quality Monitoring Station (CAAQMS) are already in operation.

II. Proposal for involving private participation in the management of Continuous Ambient Air Quality Monitoring Station / Network under the two proposed options of (1) Build, Own & Operate contract; and (2) Operation contract - Pilot project for the identified city. After analyzing description, merits & demerits of possible models of private participation in the management of CAAQMS, it was decided that the following two models may be adopted in the identified cities as pilot project:

- Model- I: Build Own & Operate (BOO) contract (investment and operation)

[16] http://www.cpcb.nic.in/Highlights/Highlights04/ch-8.html

- Model-II: Operation contract

Accordingly, a project proposal is made to execute Model I in two cities and Model II in other two cities.

There are a number of international initiatives/network on air quality active in the region, such as Clean Air Initiative (managed by the World Bank), Asian Regional Air Pollution Research network (AIRPET), coordinated by the Asian Institute of Technology and sponsored by Swedish International Development Agency.

Mission of Clean Air Initiative for Asian cities is to promote and demonstrate innovative ways to improve the air quality in Asian cities through partnerships and sharing experiences[17]. The CAI-Asia Partnership consists of representatives from local governments, national governments, civil society, academics, the business sector, and development organizations who are committed to promote better air quality management in the cities of Asia. The main goals of the CAI-Asia Partnership are:

- Encourage the development and adoption of sound science as the basis of urban AQM;
- Stimulate the development and implementation of policies, programs and projects on urban air quality; and
- Review progress in urban AQM in Asia and outline future priorities for urban AQM; and
- Foster coordination and cooperation with other regional programs and initiatives on urban air quality management in Asia.

Several governmental departments including CPCB and NGOs are member of this initiative. Several studies on air pollution monitoring are carried out under this initiative. Under AIRPET, recently, a monitoring program for particulate matter pollution was designed and implemented in six Asian cities/metropolitan regions including Chennai in India..

In respect of transboundary air pollution, India is a party to the Male Declaration, an initiative involving some countries of South Asia and Acid Deposition Monitoring Network (EANET) in East Asia, coordinated by the UNEP Regional Centre for Asia and the Pacific. As part of the implementation of Male' Declaration, the first monitoring station in India to study the transboundary effect of air pollutants has been established at Port Canning, Sunderbans. This study assesses the Air quality parameters like RSPM, NO2, and SO2. Monitoring for wet and dry deposition is being conducted at the station for the last one year. Similarly, at the national level, for transboundary issues of air quality management involving different States, an independent coordination mechanism needs to be established for networking among the concerned agencies.

3.3 AIR QUALITY MODELLING

While air pollutions cause local problems, increasing contribution of atmospheric pollutants like nitrogen oxide (NOx), carbon monoxide (CO) and volatile organic compounds to global and regional environmental changes has received much attention in recent years especially over the tropical regions. In India, given growing urbanization, rapid increase in vehicle population and growing demand for clean environment, managing urban air quality is at the centre of all attentions. However, primarily because of international initiatives, concerns over transportation of air pollutants are observed.

Application of air quality modelling to manage local air quality is increasing in India. Of late, India is also taking part in several regional and international initiatives that apply models

- to understand close links between abatement strategies of local air pollutions and GHG emissions,
- to achieve effective management of local and global pollutions, and
- to understand trans-boundary transport of air pollutions.

This section presents India´s air quality modelling capacity to deal with air pollution problems first at local scale and then at regional and global scale.

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17 http://www.cleanairnet.org/caiasia/1412/channel.html

3.3.1 Urban air quality modelling

Air pollution consistently ranks as one of the major environmental concerns and primary cause of adverse health effects on human beings. In India, estimated annual health damage of pre-euro vehicle emissions for 25 Indian cities has been estimated between US $14 million and US $191.6 million per city (Mashelkar Committee 2002). In general, the average cost amounts 0.26% of income due to highly subsidized treatment.

In India, main focus on air quality management is on urban areas, in particular, large cities. Air quality management (AQM) includes monitoring, modelling and control of air emissions to eliminate or limit its impact on surrounding environment (Jain and Khare, 2008). Figure 1 presents the different components of air quality management. An AQMS brings together the scientific activities of determining air pollution emissions, ambient concentrations by pollution type, and resulting health impacts with political and regulatory aspects to formulate a society's reaction to air pollution. Being able to identify different air pollution sources accurately is a key element in an effective air quality management system (AQMS).

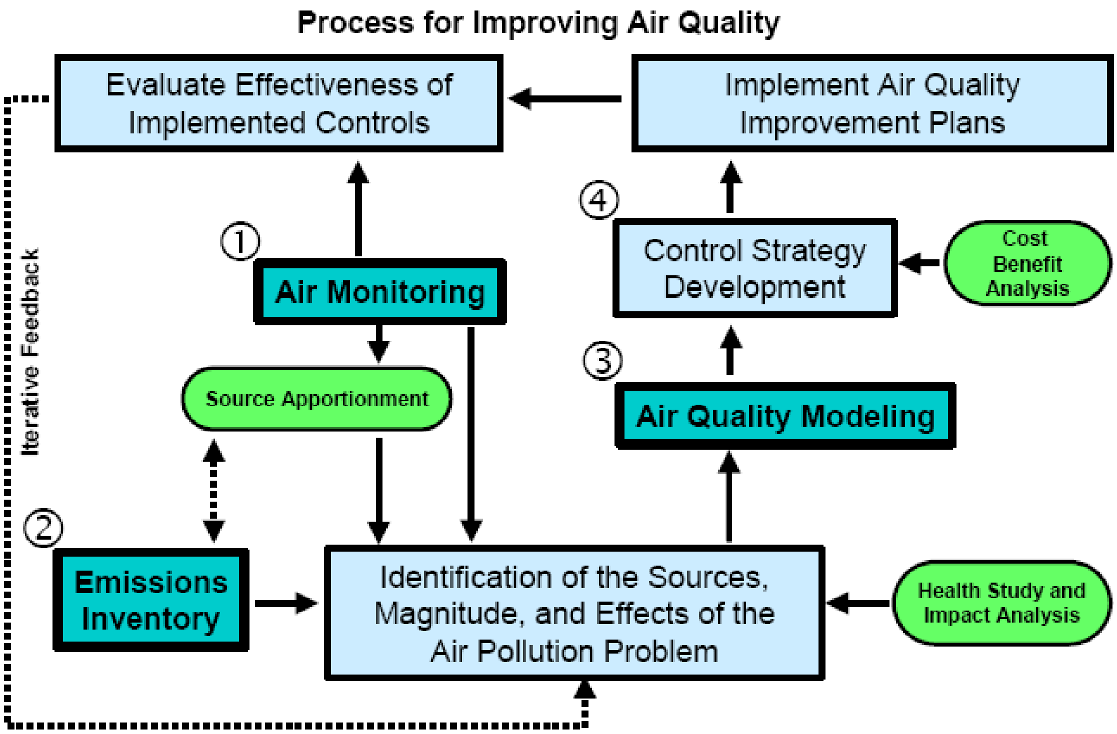

Figure 1: Process for improving air quality. Source: PREIS, 2004

A cost-effective approach for improving air quality in polluted areas involves (CPCB, 2007):

- identification of emission sources;
- assessment of extent of contribution of these sources on ambient environment;
- prioritising the sources that need to be tackled;
- evaluation of various options for controlling the sources with regard to feasibility and economic viability; and
- formulation and implementation of most appropriate action plans.

Identifying, which air pollution sources are major contributors to elevated ambient concentrations of critical pollutants, is the first step toward designing an effective policy package for air quality management. In South Asia, this question is especially relevant for sources of airborne PM2.5 (particles smaller than 2.5 microns, also called fine particulate matter), which is a major health concern[18] and India.

[18] http://siteresources.worldbank.org/PAKISTANEXTN/Resources/UrbanAir/WhatDoWeKnow.pdf

Air quality models use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere[19]. Based on inputs of meteorological data and source information like emission rates and stack heights, these models are designed to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions within the atmosphere.

These models are important for air quality management system because they are widely used by policy making agencies or regulatory authorities tasked with controlling air pollution to both identify source contributions to air quality problems and assist in the design of effective strategies to reduce harmful air pollutants. For example, air quality models can be used during the permitting process to verify that a new source will not exceed ambient air quality standards or, if necessary, determine appropriate additional control requirements. In addition, air quality models can also be used to predict future pollutant concentrations from multiple sources after the implementation of a new regulatory program, in order to estimate the effectiveness of the program in reducing harmful exposures to humans and the environment. The most commonly used air quality models include the following:

- *Dispersion Modelling* - These models are typically used in the permitting process to estimate the concentration of pollutants at specified ground-level receptors surrounding an emissions source.
- *Receptor Modelling* - These models are observational techniques which use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations.

In addition to these two types of modelling, health impacts of air pollutions are also quantified and analysed through models, which are important for policy making.

Dispersion modelling in India

In India dispersion modelling is widely used by the regulatory agencies as well as academic and research institutions. Traditionally Indian organizations have been using Industrial Source Complex (ISC) model developed by the U.S. Environmental Protection Agency (USEPA) which is freely available. This is also because of USEPA or USAID are very active in this field in India.

The ISC model, based on an advanced steady-state Gaussian plume equation, calculates chemical concentrations at specific downwind locations as a function of wind speed, atmospheric stability, temperature gradient, mixing height and downwind distance. It can account for plume rise, building downwash effect, settling and dry deposition of particulates, receptor elevation and complex terrain adjustment. At each receptor location, the computed concentrations are weighted and averaged according to the joint frequency of occurrence of wind-speed and wind-direction categories, classified by the Pasquill-Gifford atmospheric stability categories.

Two separate versions of the ISC model are available to permit both long-term and short-term air quality impact analysis. The primary difference between the two models is the type of weather data needed as input. The short-term version, ISCST, was designed to calculate contaminant concentrations over time periods as short as one hour. The ISCLT model can be used to calculate ambient concentrations over longer time periods (for example one year), simply by averaging the hourly predictions over the appropriate averaging period. Because the ISCST predictions are based upon more detailed meteorology inputs, the predictions from the ISCST model are more accurate than those estimated using the ISCLT model.

ISCST is used by CPCB for environmental impact assessment (EIA) of industrial projects (which is mandatory for all large projects) as decision making tool to give them permissions. According to many modelling experts in India, ISCST is an outdated model. More sophisticated models, such as AIRMOD[20], are available. However, they need more data which are not available in India and generating them need sophisticated laboratory facilities to conduct chemical analysis, technical capacity and financial resources. In many occasions, these models do not suit under Indian condition and cannot be changed since source codes are not available. For example, ISCST model is made for

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[19] http://www.epa.gov/scram001/aqmindex.htm

[20] http://www.colorado.edu/geography/babs/empact%20draft%20web%2018apr%2004/about%20aermod.htm

a more homogenous type of traffic, which is not common in India. Also ISCST is a steady state model, which is one of its limitations. The meteorological conditions are assumed to remain constant during dispersion from source to receptor, which is effectively instantaneous.

Other than CPCB, a number of studies are carried out by academics and research institutions very often as a joint efforts with international organizations like the World Bank, USEPA/USAID etc, who are the project financiers as well. With funding from USAID, together EPTRI, NREL, USEPA, and other technical experts prepared a thorough emissions inventory of 558 stationary sources, performed mobile source emissions modeling, conducted air quality and health effects modeling, developed several policy and transportation scenarios aimed to reduce future-year emissions, and evaluated the human health and economical impacts of the scenarios for Hyderabad city (IES, 2004). Considering the scarcity of data in Indian conditions, the Industrial Source Complex (ISC3) model is used to assess pollutant concentrations from a wide variety of sources associated within the study area.

Sharma and Chandra (2008) chose Kanpur city which is a top-ten urban conglomerate in India (based on population) for the application of the ISCST3 model and simulation of air quality. Sectoral emission loads are estimated for transport, industrial, power, and domestic sectors, which provide an estimate of the major contributors to air pollution with specific reference to particulate matter, which is a major pollutant of concern. Dispersion modelling is carried out using the ISCST3 model, to estimate the concentrations of SPM all over the city under different scenarios.

The ISCST model has been used to study the impact of an industrial complex, located at Jeedimetla in the outskirts of Hyderabad city, India, on the ambient air quality (Ramakrishna et al., 2005). The emissions of SO2 from 38 elevated point sources and 11 area sources along with the meteorological data for 2 months (April and May 2000) representing the summer season and for 1 month (January 2001) representing the winter season have been used for computing the ground level concentrations of SO2.

In addition to the ISC model, models are developed to carry out academic and research exercise at IITs and other research institutions. However, resource is main constraint to carry out detailed and sophisticated analyses of this kind.

Receptor Modelling

Receptor models are mathematical or statistical procedures for identifying and quantifying the sources of air pollutants at a receptor location. Receptor models use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations. Contributions are quantified from chemically distinct source-types rather than from individual emitters.

According to the World Bank, no more than a dozen source apportionment studies appear to have been conducted in India, and most of them identify major sources without quantification[21]. The majority have concentrated on TSP. There has been only one study attempting to investigate source contributions to PM10. Chemical Mass Balance (CMB) model developed by EPA is the most popular. CMB fully apportions receptor concentrations to chemically distinct source-types depending upon the source profile database[22]. The EPA-CMB Version 8.2 uses source profiles and speciated ambient data to quantify source contributions. CMB requires speciated profiles of potentially contributing sources and the corresponding ambient data from analyzed samples collected at a single receptor site. However, sources with similar chemical and physical properties cannot be distinguished from each other by CMB. There are other models too, UNMIX models as well as the Positive Matrix Factorization (PMF) method for use in air quality management.

Of late, use of receptor modeling is increasing in India. As stated earlier, particulates are main concern in India. There are many sources of particulate pollution: large industrial plants, medium- and small-scale industries, refuse burning, households burning biomass for cooking and heating, vehicular exhaust, re-suspended road dust, construction, particles migrating from other regions, and naturally occurring dust. These sources emit particles of varying sizes—small particles affect public health

[21] http://siteresources.worldbank.org/PAKISTANEXTN/Resources/UrbanAir/WhatDoWeKnow.pdf

[22] http://www.epa.gov/scram001/receptor_cmb.htm

much more than large particles. It is important to have a good understanding of the level of exposure of the general public to particulate air pollution, and of the relative contributions of these different sources (referred to as source apportionment)[23].

The Auto Fuel Policy document of the Government of India recommended for carrying out source apportionment studies (Mashelkar, 2002). Accordingly, source apportionment studies have been initiated in six major cities viz. Delhi, Mumbai, Chennai, Bangalore, Pune, and Kanpur. Source apportionment studies, which are primarily based on measurements and tracking down the sources through emission characteristics profiling, and receptor modelling help in identifying the sources & extent of their contribution (CPCB, 2007). The scope for source apportionment studies includes preparation of emission inventories, monitoring of ambient air quality for various pollutants (SPM, PM10, PM2.5, SO_2, NOx, CO, HC, VOC, etc.) at selected locations (7 – 10 locations covering different land uses viz. residential, industrial, kerbside, background, etc.), chemical speciation of PM10 and PM2.5 as well as source emissions, application of dispersion & CMB8 models to assess the contribution from various sources, future projections and evaluation of various control options to develop cost-effective action plans. Besides, separate projects on development of emission factors for vehicles and Development of emission profiles for vehicular as well as non-vehicular sources have also been taken up, which would provide necessary inputs to source apportionment studies. Project is being monitored by Steering and Technical Committees, headed by the Secretary, Ministry of Environment & Forests and Chairman, Central Pollution Control Board respectively. Reports of this study are not yet made public.

A number of studies are carried out by research institutes/NGOs very often in cooperation with international organizations who also sponsored the projects. The Georgia Institute of Technology, United States, in collaboration with the National Physical Laboratory, the Indian Institute of Technology (Mumbai), and the National Environmental Engineering Research Institute carried out an analysis of ambient PM2.5 in Delhi, Kolkata, Mumbai and Chandigarh using a CMB modelling (Chowdhury et al., 2007). A number of cities in India are currently developing action plans to improve air quality. The results of this study underscore the importance of basing, to the extent possible, strategies on city-specific data on the mix of emission sources and meteorological parameters.

Asian Regional Research Programme on Environmental Technology (AIRPET) coordinated by Asian Institute of Technology, Bangkok and funded by SIDA, carried out monitoring for fine and coarse particles continuously in 6 cities in Asia which include Chennai in India (AIRPET, 2007). The Indian Institute of Technology, Madras was the Indian partner. The project used two models - Chemical Mass Balance (CMB) and Positive Matrix Factorization (PMF) with source profiles mainly from literature to analyse PM composition data.

AIT team also developed two new receptor models: Dual-site Receptor Model (DUALM) and Evolutionary Receptor Model (EVORM). DUALM has been developed to simultaneously identify the contributing sources at two ambient monitoring sites, where certain similar/common sources exist. EVORM is based on the Evolutionary Programming and combines the advantages of both CMB and multivariate approaches. Both new models have been successfully tested using the available QA/QC data sets and now are used to analyze the AIRPET data. AIT claims that this activity produces the first comprehensive detail source profiles for major sources in the developing countries in Asia, which include not only ionic, elements and BC/EC and OC species, but also other organic source markers such as PAHs. The data are useful to improve the receptor modelling results. At present, most of the receptor modelling in the region is based on source profiles developed in USA (Speciate database) which may not be relevant. Similarly, emission factors produced by the project will be useful for emission inventory for the region.

According to the World Bank, the majority of the source apportionments studies have concentrated on TSP. There has been only one study attempting to investigate source contributions to PM10. These studies use US EPA source profiles which are not suitable for India resulting into incorrect conclusions. There are some of the academic and research institutions carrying out receptor modelling different from CMB. CSE suggests to enhance capacities in pollution apportionment (pollution loads by sources).

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[23] http://siteresources.worldbank.org/PAKISTANEXTN/Resources/UrbanAir/WhatDoWeKnow.pdf

Analysing impacts of air pollution

Impacts of air pollution is and important policy issue. Time to time, CPCB assigns the health impact study to academic and research institutions[24]. A number of studies are carried out on this issue by NGOs, academic institutions or through international initiatives (Srivastava and Kumar, 2002; Shankar and Ramarao, 2002; Cropper et al, 1997). Main focus is on urban air pollution, in particular impacts of particles.

In IES (2004) study, the magnitude of health impacts in relation to PM10 concentration was calculated using both a health risk assessment approach and percent increase of mortality or morbidity per unit increase of air pollutant concentration. The study used the Air Pollution Health Effects Benefits Analysis Model (APHEBA) to evaluate the benefits and costs associated with change in atmospheric PM10 concentrations, both spatially and temporally. APHEBA is a tool that uses locally derived concentration response functions to link annual average air pollutant concentrations with a specific health effect. Health effects experts of the project used APHEBA to analyze the expected air pollution health impacts for different scenarios. The IES analysis provides Indian policy makers with quantitative analyses and recommendations on how best to improve air quality reduce human health impacts, and reduce greenhouse gas emissions while meeting economic development objectives in the city of Hyderabad.

3.3.2 Regional/Global Modelling

RAINS-ASIA

In India, the main threat of an acid rain disaster springs from its heavy dependence on coal as a major energy source. Even though Indian coal is relatively low in sulphur content compared to the nature of coal reserves of other countries, what threatens to cause acid rain in India is the concentrated quantity of consumption that is expected to reach very high levels in some parts of the country by 2020.

The RAINS-Asia model offers the opportunity to assess sulphur deposition and ecosystems protection levels resulting from different energy pathways and different emission control strategies. The RAINS-Asia model has been developed as an analytical tool to help decision-makers analyse future trends in emissions, estimate regional impacts of resulting acid deposition levels, and to evaluate costs and effectiveness of alternative mitigation options. The costs of various control options are also provided. Developed by a team of Asian, European, and North American scientists, under the leadership of the World Bank and the Asian Development Bank, the RAINS-ASIA model combines sectoral energy use, sulphur dioxide emissions, abatement approaches, a long-range transport model for dry and wet deposition of sulphur dioxide and sulphate, and regional environmental effects of sulphur deposition[25]. The methodology is expected to contribute to the development of regional policy on acid deposition and trans-boundary pollution.

GAINS-Asia

Air pollution and greenhouse gases are often generated by the same sources and interact in the atmosphere through complex chemical reactions. Simultaneous air pollution and greenhouse gas mitigation is considered by air pollution and climate experts to be the most economically efficient method of improving local air quality while addressing climate change.

IIASA is now working with Indian and Chinese partners to implement a state-of-the-art co-benefits model that will assess the environmental and economic benefits of concurrent reductions of the major air pollutants and greenhouse gases. The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model identifies least-cost approaches for further improving local and regional air quality while controlling emissions of various greenhouse gases. The model addresses the near- to medium-term planning horizon (5–20 years) and covers all provinces in China and all states in India.

The GAINS model, an extension of the RAINS air pollution model, allows the assessment of emission control costs for the six greenhouse gases covered under the Kyoto Protocol (CO_2, CH_4, N_2O and the

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24 Personal communication with CPCB

25 http://www.teri.res.in/teriin/news/terivsn/issue1/specrep.htm

three F-gases) together with the emissions of air pollutants SO_2, NOx, VOC, NH_3 and PM. The project is funded by the European Commission (http://www.iiasa.ac.at/web-apps/apd/gains/). TERI is the Indian partner. The GAINS Model consists of several screen options, which display information pertaining to:

- Economic Activity Pathways; activities causing emissions (energy production & consumption, passenger & freight transport, industrial and agricultural activities, solvent use, etc.)
- Emission Control Strategies; the evolution of emissions and control over a given time horizon
- Emissions Scenarios; emissions are computed for a selected emissions scenario (combination of energy pathway and emissions control strategy), emission factors, results displays, and input values are also available under this action
- Emission Control Costs; displays emission control costs computed for a selected emissions scenario
- Impacts; presents ecosystem sensitivities and human health impacts of air pollution
- Data Management; provides an interactive interface where owner-specific data can be modified, updated, exported, and downloaded.

The GAINS model is open to the public for use. A registration is required. However, GAINS-ASIA is yet to be made available to the public. A training workshop has been organised by TERI on the use of GAINS. However, CPCB is neither aware of the model nor the project.

MOZART

Atmospheric chemistry and aerosols affect climate both directly and indirectly through other components of the Earth system. The direct influence is through greenhouse gases such as methane (CH_4), ozone (O_3), nitrous oxide (N_2O), the chloro-fluoro-carbons (CFCs), plus the absorption and scattering of light by various aerosols (e.g. sulphate, nitrate, dust, sea-salt, organic carbon, and black carbon). Regional modelling of atmospheric trace gases and particulate matter is of major importance for air pollution studies as well as climate considerations. Driven by the meteorological model, the chemistry transport model treats the atmospheric transport as well as chemical transformations for several gas phase species and particle populations. Gas−phase and aerosol species can often be transported over long distances, so that regional pollution becomes a problem on the continental or global scale.

MOZART (Model of Ozone And Related Tracers) is a state-of-the-art global chemistry transport model, which was developed jointly at the National Centre of Atmospheric Research (NCAR) in Boulder, Colorado, the General Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey, and the Max Planck Institute for Meteorology in Hamburg. It is a widespread concern in recent time that elevated concentrated of ozone in the boundary layer has severe impacts on human health and vegetation. The Indian Institute of Tropical Meteorology (IITM) has used a chemistry transport model MOZART (Model for Ozone and Related Tracers)-2 to investigate the special behaviour in the distribution of boundary layer ozone and its precursors over the Indo-Gangetic plains (Beig and Ali, 2006).

3.4 SOME INTERNATIONAL INITIATIVES

3.4.1 Task Force on Hemispheric Transport of Air Pollution (HTAP)

To develop a fuller understanding on long-range inter-continental transport of many air pollutants, the Executive Body of the UNECE Convention on Long-range Trans-boundary Air Pollution[26] has established a Task Force on Hemispheric Transport of Air Pollution. The Task Force serves as a forum for international scientific communication and collaboration and as a bridge between the international research community and the international policy community. The Task Force will work to bring the international research efforts of EMEP (Cooperative Programme on the Monitoring and Evaluation of Long-range Transmission of Air Pollutants in Europe) together with national and international research efforts at the regional, hemispheric, and global scales to develop a better understanding of air pollution transport in the Northern Hemisphere. To build these connections, the Task Force will work to encourage the participation of experts, governments, and international organizations outside of the geographic scope of the LRTAP Convention.

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[26] http://www.unece.org/env/lrtap/

HTAP is conducting a series of model evaluation and inter-comparison experiments to:

- Produce some estimates of intercontinental source-receptor relationships
- Improve our understanding of the variability and uncertainty in current model estimates
- Guide future model developments to decrease uncertainties in source-receptor relationships

The model inter-comparison and evaluation efforts are open to all interested participants. Interested experts can register to participate and get more detailed information on the complete set of model experiments, including guidance for input and requested output, at http://aqm.jrc.it/HTAP/. Indian Government is not a party to the Convention, however, scientist from IITM, Pune, is attending the meetings.

HTAP could in a next phase (after 2009) include also India (and China)[27]. HTAP has been preparing for this by explicitly also looking at India; and inviting Indian/Chinese scientists to the meetings.

3.4.2 MICS-Asia

http://www.adorc.gr.jp/adorc/mics.html

In order to have a common understanding of model performance and uncertainties in Asia, a model inter-comparison study on long-range transport and deposition of sulphur, called MICS-Asia Phase I, was carried out during the period from 1998 to 2000. Eight models participated in the Phase-I study. The outcome of the model inter-comparison exercise was discussed at the Third Workshop on the Transport of Air Pollutants in Asia, held at IIASA in September 2000.

Currently, MICS-Asia Phase-II is running. The model inter-comparison study in Phase II aims at transport and deposition of sulphur, nitrogen compounds, ozone and aerosols in East Asia. In South-East Asia, Thailand is participating, while no organisation from India is taking part. IITM which works in this area is not aware of this forum.

3.5 CONCLUSIONS AND RECOMMENDATIONS

India has fairly extensive National Air Quality Monitoring Programme and network which has been expanded steadily over time and monitors a limited number of pollutants on regular basis. Set of pollutants monitored are inadequate to address health damage related issues. Standards should be imposed on pollutants like $PM_{2.5}$, O_3 need to be monitored regularly. The present air quality monitoring system is limited in scope and accuracy. Information transferred to CPCB is scarce, and sometimes unreliable. Reliable data are essential to adopt appropriate measures and carrying out analysis needed for policy and decision making. CPCB feels the need to modernize and amplify its monitoring system according to international standards. Internationally, the use of automatic monitoring stations is widely recommended because of its accuracy, reliability and the possibility to develop alert systems in the case of pollution peaks. Manual stations are mostly limited to some specific pollution parameters, for which automatic monitoring is not yet feasible. According to CPCB, the Indian air quality monitoring system need be modernized to address the following problems:

- Measure continuously air pollution in major Indian cities and industrial areas and compare mean and peak values with air quality standards.
- Develop air quality forecast systems and procedures.
- Standardize at the national level the monitoring and quality control procedures. Set up a valid and quality controlled local and central air quality database.
- Set up a standardized data transfer and data processing system that enables a free flow of information between cities, central government and eventually the public.
- Define clearly the responsibilities of the Central Government, States, Municipalities and industries, and organize transfer of information between these structures
- Organize the operation and maintenance procedures in order to insure good working conditions to the systems, and promote a funding scheme.

Although, installing more automatic monitoring systems may reduce the pressure on human resources of the regulatory bodies and result in more accurate data, automatic monitoring system is the most expensive method of air quality monitoring. In order to ensure that the data produced are accurate and reliable, strict maintenance, operational and quality assurance/control procedures are often required. International assistance can be useful.

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India has scientific and technical capacity base to conduct monitoring and modelling activities. However, given the size of the country, increasingly complex development process and policy making, it is neither adequate nor proportionally distributed. Capacity needs to be improved further.

Many aspects of air quality are not well-understood becoming important barriers to take appropriate measures. For example, very often source apportionments are not available creating difficulty to identify, which sources are causing damage. Various types of modelling are needed to improve the policy and decision making process. Models currently used are out-dated and weak, and databases are not sufficient to conduct sophisticated modelling activities. Generating data needs laboratory facilities and scientific and technical training to conduct the experiment and analysis. Models developed in USA and Europe are adopted and very often not suitable under local conditions leading to ambiguous results. Current modelling activities primarily concentrate on urban air quality and focus on one pollutant - particles. Other pollutants need more attention. Forecasting of air quality is one area, which needs further modelling.

Modelling activities are carried out in isolated manner across different institutes and sharing information and knowledge is poor, causing repetitions of work. The EU R&D framework, which requires a minimum number of participant institutions that complement each other, could provide useful inspiration. More network activities are also needed, both within R&D and between research institutions and policy making and regulatory bodies.

With growing economic activities and population, air pollution in India is going to increase manifold in future, causing concern in terms of trans-boundary pollutions. Given the geographical size of the country with one-fifth of global population, any international initiative (like HTAP) on this issue not involving India will remain incomplete and the outcome may be incorrect. Participating in such activities, India can extend its scientific capacity on modelling and measurement.

3.6 REFERENCES

AIRPET, 2007, Asian Regional Research Programme on Environmental Technology (AIRPET Phase II)-(2004-2007), prepared by Dr. Kim Oanh N.T and Prof. Chongrak Polprasert, Environmental Engineering and Management, Asian Institute of Technology, Bangkok.

Beig G., and Ali K., (2006), Behaviour of boundary layer ozone and its precursors over a great alluvial plain of the world: Indo-Gangetic plains, Geophysical Research Letters, Vol. 33, L24813.

Chowdhury, Z., M. Zheng, J. J. Schauer, R. J. Sheesley, L. G. Salmon, G. R. Cass, and A. G. Russell (2007), Speciation of ambient fine organic carbon particles and source apportionment of PM2.5 in Indian cities, J. Geophys. Res., 112, D15303, doi:10.1029/ 2007JD008386.

CPCB, 2007, Annual Report 2006-07, Central Pollution Control Board, New Delhi.

Cropper L.M., Simon N.B., Alberini A., and Sharma P.K., (1997), The health effects of air pollution in Delhi, India, Policy Research Working 1860, The World Bank, Development Research Group, Washington.

EPTRI, 2005, Integrated Environmental Strategies-Study for City of Hyderabad, Environment Protection Training and Research Institute, Hyderabad, India.

Jain S., and Khare, M., 2008, Urban air quality in mega cities: A case study of Delhi City using vulnerability analysis, Environment Monitoring and Assessment, 136:257–265

Mashelkar, R. A. et al., Interim Report, of the Expert Committee On Auto Fuel Policy, Government of India, New Delhi, 2002.

PREIS, 2004, Pune, India Regional Emissions Inventory Study, Prepared by: Patrick Gaffney and Michael Benjamin, and Reviewed by John Mooney and Ted MacDonald, U.S. Environmental Protection Agency.

Sharma . and Chandra A., (2008), Simulation of Air Quality using an ISCST3 Dispersion Model, Clean 2008, 36 (1), 118 – 124.

Shankar P. R., and Ramarao G. (2002), Impact of Air Quality on Human Health: A Case of Mumbai City, India, IUSSP Regional Conference on Southeast Asia's Population in a Changing Asian Context, 10-13 June 2002.

Srivastava A., and Kumar R., (2002), Economic Valuation of Health Impacts of Air Pollution in Mumbai, Environmental monitoring and assessment, Vol. 75, NO.2, pp135-143.

TERI, 2001, Review of past and on-going work on urban air quality in India, TERI Project Report No. 2001EE41, Tata Energy Research Institute, New Delhi.
WBPCB, 2004, Air quality status of West Bengal, A state of environment report 2004, West Bengal Pollution Control Board, in collaboration with Department of Environment, West Bengal,)
WB, 2005, Urban air pollution - South Asia Urban air quality management briefing note no.14.

4. COMBINED BENEFITS OF REDUCING GREENHOUSE GAS EMISSIONS AND IMPROVING AIR QUALITY

4.1 CO-BENEFITS

4.1.1 General

The response to climate change and the changes it will induce in the world's energy and transport systems, shows promise in terms of the economic, social and environmental pillars of sustainable development, in particular:

- reductions in air pollution and related health effects, and other environmental burdens;
- a better and more secure energy future;
- employment and innovation.

The International Panel on Climate Change (IPCC) defined co-benefits in its 3rd Assessment Report, 2001:

- Co-benefits are the benefits from policy options implemented for various reasons at the same time.
- Ancillary benefits are monetized secondary, or side benefits of mitigation policies on problems such as reductions in local air pollution and possibly indirect effects on congestion, land quality, employment, and fuel security.

In its 4th Assessment Report, 2007, IPPC acknowledges that co-benefits approach will offer larger benefits:

> "While studies use different methodologies, in all analyzed world regions near-term health co-benefits from reduced air pollution as a result of actions to reduce GHG emissions can be substantial and may offset a substantial fraction of mitigation costs (high agreement, much evidence).
>
> Integrating air pollution abatement and climate change mitigation policies offers potentially large cost reductions compared to treating those policies in isolation".

Co-benefits pertaining to the object of the present study (large-scale industries and power plants) are described further in subsequent paragraphs.

4.1.2 India

India and other large fast-developing countries are facing increasing pressure from developed countries to sign for binding caps on greenhouse gas emissions, possibly with the second commitment period of the Kyoto Protocol (post 2012). This has been opposed by the Government and other stakeholders in India, since it might interfere with the much-needed development of the economy. Besides, greenhouse gas emissions are very low on a per capita basis. Also, it is a general perception that the West is not doing enough to combat climate change. Developing countries may commit after 2020, if the West can show significant results of their own efforts, the argument goes.

Although there is increasing awareness and pressure to address climate change, focus in India is still on other priorities such as economic growth, access to electricity, air quality management, and energy security. Also, a general concept is that economic development will improve environmental quality (climate change seemingly being ignored). The co-benefits approach for India would therefore be one that internalizes India's priorities. The co-benefits definition would then not be climate-centric, but could be e.g. energy-security centric (for Government), energy-efficiency centric (for industries) and air-quality centric (for the general public). Applying IPCC's definition (paragraph 2.1) to the current Indian context, GHG mitigation can be conceived an ancillary benefit from pursuing other – more high priority – policy objectives.

On this background, a climate change policy cannot stand alone, but should be viewed comprehensively vis-á-vis other policy areas. Numerous studies have shown that there are many win-win benefits to be gained from implementing climate change policies, as well as climate change benefits to be gained from policies in other areas, such as economic development, health and energy. For example, reducing CO2 emissions in the EU by 10 % by 2020 would generate health benefits estimated between EUR 8 - 27 billion. In countries such as India where classic air pollutants are still a key policy issue, action on and particulate matter, SOx, and NOx often also implies a reduction in CO_2 emissions.

The authors' impression of current discussions on climate change and co-benefits in India are briefly described in this paragraph. More specific observations for the power sector and large-scale industries are described in subsequent chapters.

The energy-security approach appears to carry much more weight than the air-quality management approach, for two major reasons: Enhancing energy supply and access is the top priority for the Indian energy policy, while energy security comes in as a strong number two. Also, the link between air pollution and GHG emissions is so evident, that there is little need for further stressing this argument.

The Government's approach is to mainstream climate change in sustainable development (ref. 3):

> "*Government initiatives for the diffusion of renewable energy and energy-efficient technologies, joint forest management, water resources management, agricultural extension services, web-enabled services for farmers and rural areas, and environmental education in schools and colleges represent a broad spectrum of efforts to integrate climate change concerns in sustainable development. This integration is institutionalized through specialized institutions, such as the Ministry of New & Renewable Energy, the Bureau of Energy Efficiency, and the Technology Information, Forecasting & Assessment Council, with specific mandates to promote climate friendly technologies*."

The DNA has a very pragmatic approach towards co-benefits (in terms of CDM and sustainable development): All projects of a given size have to comply with the EIA regulation and CPCB's pollution regulations. If project developers comply with these two sets of regulations, the understanding is that the projects will per se contribute to sustainable development, and hence the DNA will automatically approve this part of the Project Design Documents.

Case: Climate change policy in West Bengal
The State of West Bengal presents an evidence of the increasing policy concern for climate change.

The Chief Minister recently established a Climate Change Cell, including a Technical Cell. For a start three activities have been scheduled:

1. The impacts on vulnerable societies and adaptation measures will be addressed in the Sundarbans (Ganges' river delta).
2. Costal zone management with climate change proofing is to be carried along the coastal line.
3. Adaptation needs in Kolkata shall be identified and addressed. The activity shall afterwards be replicated in other cities

4.2 ENVIRONMENT

4.2.1 Air pollution and greenhouse gasses

Climate-change and air-quality issues are linked in several ways:

1. The main GHG CO_2 and the main air pollutants to a large extent stem from the same sources. For a range of control initiatives, targeting these common sources thus typically implies abatement of both CO_2 and air pollutants. Several previous studies in both developing and developed countries have demonstrated that the near- to medium-term co-benefits of CO_2-abatement policies, which primarily consist of reduced damage to human health from air-quality improvements, can offset a large fraction of the mitigation costs and even exceed the costs significantly in some cases.
2. Increasing evidence exists that well-known air pollutants, especially tropospheric ozone and particles, play an important role in the climate system.
3. Climate change and air quality are linked through the chemistry of the atmosphere, as some air pollutants influence the lifetimes of GHGs.

Greenhouse gas mitigation often leads to lower emissions of other pollutants, lower pollution control costs and lower environmental impacts. Moreover, whilst the full benefit of emission reductions resulting from climate mitigation policies may be experienced only by future generations, the co-benefits will accrue to the present generation.

Fuel substitutions aimed at reducing CO2 emissions cut the costs of complying with air quality legislation. The declines in air pollutant emissions are a mere side-impact of the (fuel substitution) measures targeted at CO2 reduction in the power sector. So these emission cuts do not come at additional costs.

Some greenhouse gases, such as methane, are also precursors for tropospheric (ground level) ozone. Thus reductions in methane emissions would have co-benefits in tackling the ozone problem, i.e. damages on agricultural crops and human health. Reductions in ozone precursor substances have an effect on the sequestration of carbon in the biosphere. Therefore, a combined analysis of greenhouse gas mitigation and air pollution control leads to substantially different conclusions about the cost-effectiveness of strategies than traditional approaches that analyse these two problems in isolation.

The synergetic effects on climate change and air quality are probably the most marked for low-income but rapidly growing regions of the world, i.e. mostly in Asia. As climate change policies induce significant changes from baseline for sulphur and nitrogen oxide emissions, they will bring substantial co-benefits in terms of reduced regional air pollution, and improved human health. For certain countries, air quality benefits could indeed be the major driving force for taking action and participating in a future climate regime.

An OECD study from 2001 (ref. 4) highlighted the synergy between slowing greenhouse gas emission growth and improving local environmental quality in India. With the aid of a computable general equilibrium model, the study estimated for India the magnitude of ancillary benefits from limiting growth of greenhouse gas emissions to local air quality and the health of the urban population. The most important co-benefit is reductions in emissions of particulates with associated declines in mortality and morbidity. By valuing these co-benefits, the study compared them with the welfare costs of climate policy (represented by a uniform carbon tax), estimating that — on conservative assumptions — emissions could be reduced by somewhat more than 10 per cent from their 2010 baseline level without incurring net costs. With central estimates of substitution elasticities and willingness-to-pay for health improvements, “no regrets” abatement could reach around 17-18 per cent of baseline emissions.

In valuing impacts on human health the study used the estimated value of statistical life (VSL), using USD 273,000 as central VSL estimate. The study considered only the health impacts, leaving aside any other impacts from air pollution.

The analysis also assessed the inter-regional variation in costs and benefits, finding that abatement costs are relatively low and ancillary benefits high in North and East-Northeast. Without an explicit redistributive mechanism, one region (the South) would enjoy no net benefits from climate policy.

The analysis explicitly ignored the longer term and more uncertain benefits that might accrue to India from averting climate change, on the assumption that — given the long time horizon and the remaining uncertainties — these are unlikely to have much impact on current policy making.

The Environmental Protection and Training Research Institute (EPTRI), with the assistance of US Environmental Protection Agency (US EPA) and US Agency for International Development (US AID), conducted the Integrated Environmental Strategies in India (IES-India) from 2002 to 2004. The city of Hyderabad, Andhra Pradesh, was selected as the project site. The IES-India team also included Institute of Health Systems, Hyderabad, RITES, New Delhi, Winrock International (India), and the Confederation of Indian Industry (CII), Hyderabad. EPTRI identified strategies to improve ambient air quality while also reducing associated GHG emissions.

The project estimated the effects of alternative transportation scenarios on air quality and associated GHG emissions. In addition, scenarios were developed by EPTRI to consider how Hyderabad’s growing industrial sector could most effectively limit the growth of its air pollutant and GHG emissions, including: Use of additives in boiler fuel oil; Use of particulate controls on all uncontrolled solid waste fired boilers; Use of natural gas in coal fired boilers; and Use of renewables (biomass gasification) in fuel oil boilers.

Indian and European researchers have cooperated in the EC-funded GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) project, which was recently completed (www.iiasa.ac.at/web-apps/apd/gains/).

As appears from the project title, GAINS has studied the co-benefits from reducing air pollution and GHG gasses. The study has covered many countries and many pollutants[28]. For India some key results are:

- Air pollution will grow, despite current legislation; SOx by factor 6 and NOx by factor 4 between 2000 and 2030.
- Substantial mitigation cost savings and socio-economic benefits from applying cost-effective end-of-pipe measures and structural changes.
- These measures lead, as a co-benefit, also to lower CO2 emissions.

The co-benefits approach will be the main theme of the Asia-Pacific Better Air Quality 2008 workshop scheduled for October - November 2008. The workshop is organised by Clean Air Initiative for Asian Cities Centre (www.cleanairnet.org/caiasia).

4.2.2 Health impacts

Lower air pollution emissions mean better air quality, and therefore. less human exposure to fine particles, SO_2 and NOx.

As a result, even modest climate policies (in terms of costs) may have relatively large financial co-benefits in terms of avoiding the most expensive air pollution control measures.

The above-mentioned OECD-study (ref. 4) focussed specifically on the link between climate policy and local air pollution by quantifying and valuating both the ancillary benefits of climate policy (e.g. fewer premature deaths, lower incidence of respiratory illness) and the costs of adjustment towards a less carbon intensive economic structure. Most of the health benefits from improved air quality are expected to come from reduced particulate emissions and concentrations (including secondary particle formation as sulphate and nitrate aerosols).

The OECD-study quotes earlier studies on the number of premature deaths associated with pollution concentrations above the WHO guidelines. Based on 1991-92 air quality and population data, this number totalled 40,351. Using 1995 air quality data, air pollution related deaths had risen to 51,779.

The study showed lives saved per million tonnes of carbon abated equal to 334, compared with 298 for China. The numbers for developed countries are considerably lower. Developing countries with few initial local pollution controls (hence, little delinking of CO2 emissions from other pollutants) are likely to benefit more in lives saved from climate policy than developed countries where such delinking is far more advanced. Another factor in the cases of China and India is the high urban population densities, hence, large exposed populations relative to developed countries.

IES-India (ref. 6) calculated the health impacts using cases of respiratory illness, hospital visits, emergency room visits, and other health end-points. IES researchers also conducted an economic valuation of the health effects of air pollution using methodologies such as the Cost of Illness (COI) approach and willingness to pay assessments based on local information where available and on studies done internationally, and adapted as appropriate, using a benefits transfer approach.

The magnitude of health impacts in relation to PM10 concentration was calculated using both a health risk assessment approach and percent increase of mortality or morbidity per unit increase of air pollutant concentration.

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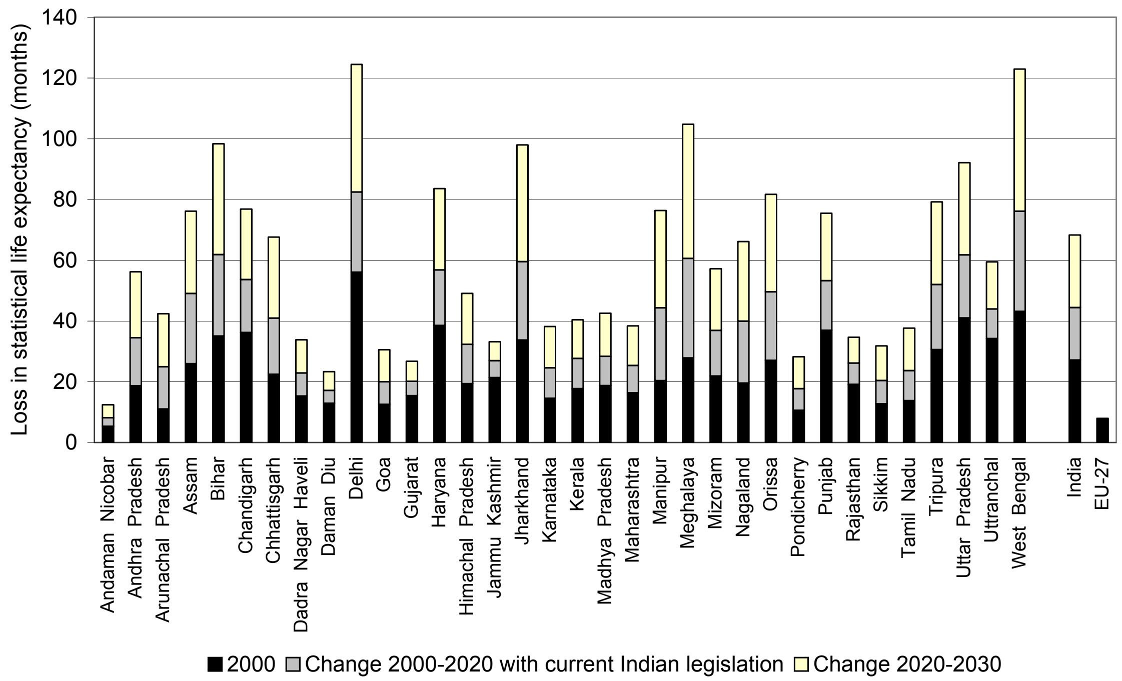
28 Pollutants: Ammonia (NH_3), Carbon dioxide (CO_2), Methane (CH_4), Nitrogen oxides (NO_x), Nitrous oxide (N_2O), Particulate matter (TSP, PM10, PM2.5 and PM1), Sulphur dioxide (SO_2), and Volatile organic compounds (VOC).

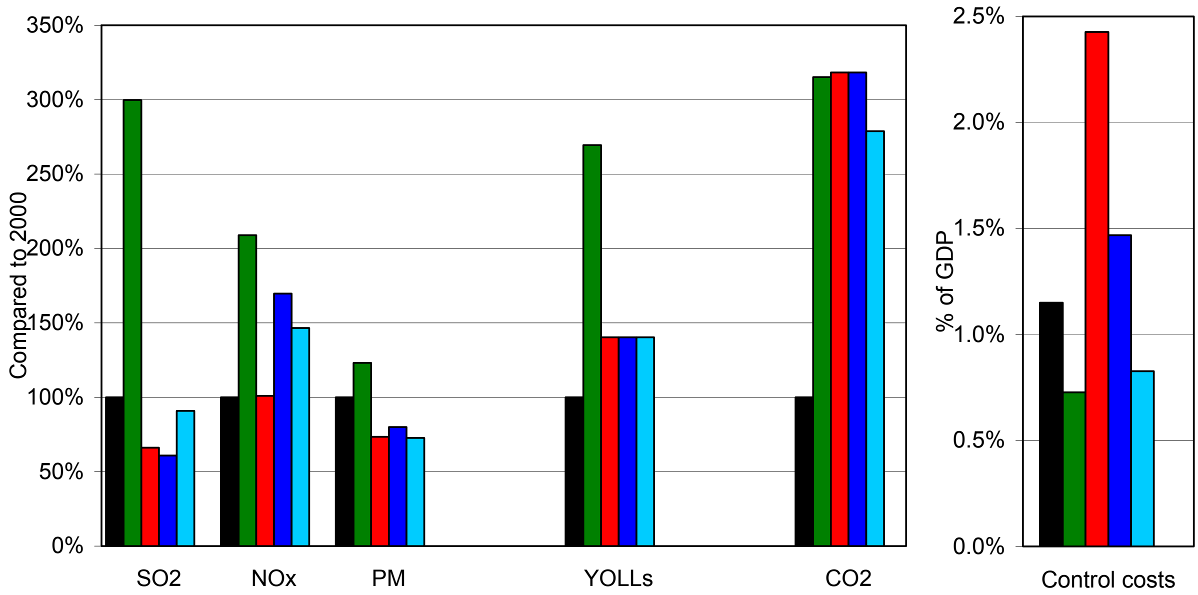
The study found that mobile source emissions are currently the largest sector of GHG and air pollutants in Hyderabad - approximately 63% of total emissions in 2001; increasing to 75% by 2021 under Business-as-Usual (BAU) assumptions. While morbidity and mortality would be reduced from PM10 concentrations in other industrial mitigation scenarios, the transportation sector offers the greatest opportunity for human health improvements and greenhouse gas reductions. Implementing reduction measures within the transportation sector would prevent an estimated 2,000 to 20,000 deaths from long-term exposure to PM10 concentrations and 1,500 to 7,500 deaths from short-term exposure to PM10 concentration in 2011 and 2021 respectively. Hospital admissions were estimated to be reduced by 650 cases in 2011 and over 5,000 cases in 2021. Effective bus transit mitigation measures resulted in a 33% reduction of PM10 concentrations compared to BAU levels. The estimated annual monetary value of the health benefits from the avoided mortality of the effective bus/transit mitigation measures range from USD 112 million in 2011 to USD 1,208 million in 2021. The economic benefits of avoided cardiovascular and respiratory diseases from the effective bus/transit mitigation scenario range from US $10 million in 2011 to USD 506 million in 2021.

The GAINS project (cf. paragraph 3.1) estimated ecosystem sensitivities and human health impacts of air pollution. The below figure shows the loss in statistical life expectancy (months for person) attributable to PM2.5 in Indian states and the national average:



The average loss in statistical life expectancy is estimated to grow from about 25 months in 2000 to about 45 months in 2020 and about 70 months in 2030, provided no further regulation of the emissions of small-size particulates is legislated.

GAINS also estimated the economic costs and benefits of various air pollution control strategies. The below figure shows (left graph) present (2000; black columns) and forecasted (2020) emissions and health impacts (years of life lost, YOLLs) together with (right graph) the mitigation costs of control strategies (percentage of GDP):



The analysed control strategies are:

Case 1: With current Indian legislation (green columns)

Case 2: Apply standard Western end-of-pipe technologies at all sources (red columns)

Case 3: Search with the GAINS optimization mode for the cost-effective set of measures that achieve in 2020 the same health impacts (YOLLs) as in Case 2 with end-of-pipe air pollution control technologies only (dark blue columns).

Case 4: Search with the GAINS optimization mode for the cost-effective set of measures that achieve in 2020 the same health impacts (YOLLs) as in Case 2 with end-of-pipe air pollution control technologies plus including structural changes and advanced coal technologies (light blue columns).

Several observations can be made from this figure. One is that by 2020 the years of life lost can be reduced to half (Case 4), compared with maintaining current legislation (Case 1), with a slight increase in control costs (from about 0.7% to about 0.8% of GDP), while GHG emissions – as a co-benefit - will be reduced from about 320% to about 280% of current emissions.

The GAINS project is probably the most comprehensive attempt to estimate the co-benefits of improved air quality and greenhouse gas mitigation for India (among others). The project and its results are little known outside a few academic institutions, and it is therefore recommended that the project outcome be disseminated widely, not the least to policy makers and public authorities.

Case: Health impacts of air pollution on the Kolkata population

A World Bank study on air quality data from 1992 suggested additional premature deaths of 5,700 people, while a similar study conducted by the Centre for Science and Environment (CES, New Delhi) suggested air pollution related additional deaths of 10,600 in 1996.

A more recent study (1998-2001), conducted by the Department of Environment, Government of West Bengal, and West Bengal Pollution Control Board, indicated that the Kolkata population is much more susceptible to respiratory disorders than rural people. 41% of Kolkata population suffer from upper respiratory tract symptoms, against 14% observed in rural Bengal. Similarly, 48% of Kolkata population suffer from lower respiratory tract disorders, compared to 35% for rural population. Lung function tests of city population indicate 47% of the individuals surveyed have impaired lung capacity with both restrictive and obstructive lung impairment. Persons occupationally exposed to higher levels of air pollution, such as street hawkers and garage workers, displayed very severe lung impairment.

The study also assessed the burden of particulate matter using the presence of Alveolar Microphages

(AM) in the deep sputum as biomarker. High AM levels may cause damage to lung architecture leading to emphysema. The AM count in Kolkata population was about 7 times higher than its rural counterpart (result not biased by smoking habits). Females had more AM in their lungs than males, the difference probably caused by air pollution from domestic cooking.

Source: ("Pollution Prevention and Waste Minimisation of Small Scale Industrial Units in Kolkata Metropolis Area". Final Report, March 2007. Joint WBCPB – ICEF (India-Canada Environment Facility).

4.2.3 Agricultural impacts

Ozone (O_3) has detrimental effects on a variety of receptors, e.g. humans, animals, aquatic ecosystems, forests, and agricultural crops, and is thought to contribute to the decay of urban buildings and other structures.

Ozone is the most important pollutant with respect to plant injury. Ozone injury on plant leaves is usually characterized by upper leaf surface chlorosis (yellowing), stippled or mottled markings or by a 'bronzed' appearance.

In the lower atmosphere, ozone is produced mainly by photochemistry from industrial and other anthropogenic emissions of CO, HC, and NOx, from burning of the fossil fuels and biomass, as well as from natural emission sources including lightning, wildfires, soils, and vegetation.

Tropospheric ozone is also an important greenhouse gas. Ozone affects climate, and climate affects ozone. Temperature, humidity, winds, and the presence of other chemicals in the atmosphere influence ozone formation, and the presence of ozone, in turn, affects those atmospheric constituents.

Tropospheric ozone in the Indian sub-continent has been simulated with an episodic chemical transport model christened HANK (ref. 5). The simulated results were compared with measured data.

AOT40 -a parameter that represents the accumulated dose of ozone over a threshold of 40 ppb is computed using the simulated ozone values. Ozone concentration greater than 40 parts per billion (ppb) in the surface air affects the agricultural crop yields and also the production, vitality, and stress tolerance of forest trees. AOT40 is the sum of the differences between the hourly mean surface ozone concentration (in ppb) and 40 ppb for each hour when the concentration exceeds 40 ppb, accumulated during daylight hours.AOT40 is used to determine the ozone uptake by plants. AOT40 equal to 3000 ppb hours (ppbh) over a period of three consecutive months is associated with a five percent reduction in the yield of spring wheat in six European countries. This value is accepted as the critical level of ozone for a reduction of yield in crops.

Based on this analysis, surface ozone is much above critical levels, as AOT40 is greater than 3000 ppbh at most places in the Indian region. It is of significant concern for agricultural productivity. Values vary between 100 and 19,000 ppbh with maximum values in the Indo-Gangatic plain in the Northeast region of India. There is substantial temporal and spatial variation in ozone across the region due to meteorological conditions and anthropogenic emissions of precursor gases. Ozone concentrations are higher in March compared to other months during February-May period.

Surface ozone levels were measured in Darjeeling in 2001 (ref. 11). However, emphasis was given to correlate the health effects with the concentration of pollutants. Impacts on agriculture were not assessed. The study showed that ozone concentration between 30 and 70 ppbv (parts per billion, volume basis).

4.2.4 Other environmental benefits

Pollution has many other impacts than on human health and agriculture, e.g. corrosion of buildings and infrastructure.

One such impact was clearly illustrated in March 2008, when Northern India faced severe power cuts, stretching up to 10 hours a day during 2-3 days, due to frequent tripping of transmission lines caused by deposits of pollution particles and fog on insulators, leading to flash-overs. According to media reports, the heavy fog was also a result of pollution.

Some suggested replacing the insulators with more pollutant-resistant polymer insulators. Others claimed that pollution reduction is the only solution. The immediate solution was to clean the lines and insulators manually.

4.3 ENERGY

Co-benefits in the energy sector:

- Energy efficiency: When CO_2 reductions are achieved through energy efficiency measures, fuel consumption will decrease, thereby improving energy security of energy supply. As India is facing rapid increases in energy demand and since there is still substantial room for efficiency improvements, the significance for energy security is paramount.
- Renewable energy: When CO_2 reductions are achieved by substituting fossil fuels with renewable energy sources, energy security is likewise improved. As India has a high renewable energy potential, also here the significance for energy security is considerable.
- Cleaner technologies: Research and advocacy for use of cleaner technologies (e.g. clean coal) are increasing worldwide. India will install large amounts of new power capacity, which allows for extensive use and adoption of advanced technologies. This is beneficial for technological innovation and economic growth.
- All three above-mentioned benefits will furthermore improve the environmental performance of the energy sector, reduce the economic risks related to security of energy supply, reduce the import dependence, and improve the trade balance of India.

Actually, the energy intensity of the Indian economy has decreased recently. Since 2004, the Indian economy has grown at a rate of over 9% per year, supported by an energy growth rate of less than 4% per year.

The risks in terms of energy security are expected to grow in the coming decades. Coal has long been the mainstay of India's energy supply, since India is endowed with significant coal reserves that are expected to last much longer than its oil and natural gas reserves. Coal consumption increased from 140 million tonne in 1984 to over 400 million tonne in 2004 with a growth rate of 5.4%. Thermal power plants using coal, account for 60% of our total generation capacity. Coal being abundant, cheap and locally available would remain a major resource of the Indian energy system for decades to come. However, due to a rapidly increasing transport sector, imports of oil products are destined to increase, thus increasing the challenges of energy security.

4.3.1 The power sector

Coal is likely to remain the dominant fuel of the power sector for many decades to come. Options that can potentially mitigate both CO_2 and air pollution from coal use include coal washing; increased efficiency of power generation; cleaning the emissions (particulate, SOx and NOx filters); and carbon sequestration (capture of CO_2 during or after combustion).

Coal washing for power generation has not been found financially attractive in India.

Particle emissions are regulated, following international standards. Indian coal has very low sulphur content, and therefore there is no SOx regulation. Also, there is no NOx regulation. Simple measures to reduce air pollutants, such as filter bags or electrostatic precipitators at coal-fired power plants, will decrease efficiency and thus increase CO_2 emissions. Thus there will be no co-benefit.

There is no economic rationale for carbon capture, since there is no potential use of the CO_2. Use of CO_2 for enhanced oil recovery is not relevant in India, since oil resources are scarce.

This leaves increased generation efficiencies as the most foremost and preferred option to reduce air pollution and CO_2 emissions. The current approach is to rehabilitate existing power plants and to install supercritical steam power plants, thereby increasing efficiencies from about 35-37 % for typical new power plants to about 41 %.

The Centre for Power Efficiency and Environment Protection (CenPEEP), which started in 1994 (funded by US Agency for International Development, USAID), is designed to reduce the emissions of GHG per unit of electricity generated by improving the efficiency of existing coal-fired power plants and by implementing advanced technologies for future coal-based power plants.

The Centre was established and is operated by NTPC, but it works also for other power companies, sometimes on consultancy basis, sometime free-of-charge. The focus is on rehabilitating existing coal power plants by performance optimization in terms of efficiency, availability and reliability. Several implemented demonstration projects have replicated, involving substantial technology transfer.

The project has been a great success, and it has won a couple of international awards. USAID considers it one of its flagship projects. A major reason for its success is its win-win approach:
Public (global/national) concerns (environmental improvement):

- GHG emission reduction
- Particulate emission reduction
- SOx / NOx emission reduction
- Effluents reduction
- Improved ash management

go hand-in-hand with utility concerns (plant productivity improvement):

- Efficiency increase
- Availability improvement
- Reduction in O&M costs
- Less capacity addition, less raw materials and fuels required
- Increased profitability
- Sustainable growth
- Dual focus: Plant load factor and efficiency.

Integrated Gasification and Gas turbine Combined cycle (IGCC) may become relevant in the future; with fluidized bed gasification, because of the high ash content of Indian coal.

Fuel-switch to a cleaner fuel, e.g. natural gas, used in high-efficiency (combined cycle) power plants will reduce air pollution and CO2 emissions substantially. However, India has no own resources, and currently gas is imported in liquefied form (LNG). Piped gas import has been considered, e.g. from Iran, Myanmar and sub-sea from the Middle East, but no decisions to actually build pipelines have yet been taken.

4.4 LARGE-SCALE INDUSTRIES

4.4.1 Air pollution

Options that can potentially mitigate both CO_2 and air pollution from coal use include coal washing; coal briquetting; co-generation of heat and electricity; a range of energy-saving and clean-coal options; and replacement, improved management, or modified design of small industrial boilers.

Studies in China have shown that several of such measures are financially profitable, with saved energy costs resulting in negative abatement costs even before any health and environmental benefits are taken into account. The individual potentials of these options to reduce CO_2 and provide health benefits (via air-pollution reductions) vary considerably, however. This implies that the ranking of abatement options according to their unit cost (per ton CO_2, when they are regarded as potential GHG options) is substantially altered when local health benefits are considered. For example, coal briquetting and coal washing seem to be among the most expensive options for reducing emissions of CO_2, but they provide large local benefits. Electricity-saving projects show the smallest co-benefit per ton CO_2 reduction, since they reduce emissions through high stacks at power plants and affect local air quality only to a very limited extent. Typically, the estimated co-benefits of CO_2 mitigation are higher in regions where emissions of air pollutants are not abated, or only abated to a limited extent.

4.4.2 Greening the industry

There are several initiatives promoting the development of environment-friendly industries, e.g. energy conservation, reduction of air and water pollution, and waste minimisation.

The Confederation of Indian Industries (CII) and the Indian Tobacco Company (ITC) launched the CII-ITC Centre of Excellence for Sustainable Development (www.sustainabledevelopment.in) in New Delhi in January 2006. The Centre shall create a conducive, enabling climate for Indian businesses to pursue sustainability goals.

According to CII, most large industries now understand climate change, in particular CDM. This understanding took off from COP 8 (New Delhi, 2002). Companies may justify climate change involvement from either a CDM perspective (improved cash flow) or from a Corporate Social Responsibility (CSR) perspective. Many investments in energy savings show very short pay-back periods and therefore need no further justification.

An additional justification for investing in clean technologies is that it is better to invest clean now, in particular when establishing new facilities, than being forced to rehabilitate existing installations by forthcoming regulations. Voluntary actions may also pre-empt government intervention.

The Steel Authority of India Ltd. (SAIL) participates in the Asia-Pacific Partnership for Clean Development, Task Force on Steel (in which 7 countries participate). This Task Force has identified 15 energy efficiency projects to be conducted.

The National Productivity Council (NPC) has conducted the Green Productivity Demonstration Program (GPDP), 2005, sponsored by the Asian Productivity Organisation (APO), Japan. Also, NPC has recently completed a project supported by US funds on small scale glass industries, linking energy efficiency and CDM.

Greening the industry is often directly attractive from an economic point-of-view. The below paragraphs describe some initiatives, where the benefits are more indirect, i.e. maintaining or expanding the market through a green image. Often climate change benefits and other environmental benefits are so intertwined that it makes little sense to define one type as the main benefit and the other as the side-benefit. Thus, they are real true co-benefits, closely integrated with economic and possibly other benefits.

4.4.2.1 Corporate responsibility for environment protection

The Ministry of Environment & Forest (MoEF) launched in 2003 a Charter on "Corporate Responsibility for Environmental Protection (CREP)" with the purpose to go beyond the compliance of regulatory norms for prevention and control of pollution through various measures including waste minimization, in-plant process control and adoption of clean technologies. The Charter has set targets concerning conservation of water, energy, recovery of chemicals, reduction in pollution, elimination of toxic pollutants, process and management of residues that are required to be disposed off in an environmentally sound manner.

The Central Pollution Control Board has made individual CREPs with several industrial sub-sectors, including with all integrated steel plants and with the cement industry. One aim is to introduce automatic monitoring of air emissions (particulate matter, CO, acid mist, SO2, NOx).

The Cement Manufacturers' Association is also active in the Cement Sustainability Initiative, under the World Business Council for Sustainable Development. According to this Initiative, cement manufacturers must disclose carbon emissions.

4.4.2.2 Green rating

The Centre for Science and Environment (CSE) has developed a green rating scheme for four industrial sectors, including pulp and paper, cement, and automobile manufacturing. They are using life-cycle analyses (approx. 200 parameters) on individual industries, which all are supplying the required data voluntarily. Each industry is giving an environmental rating, which is then used for bench-marking.

For a couple of the sectors, the rating has been carried out twice. With the first rating as baseline, companies have improved their environmental performance in the second rating. Reports can be purchased from CSE's office in Delhi or through http://csestore.cse.org.in.

Delhi School of Economics analysed the stock market at the time, when the second ratings were published. The market reactions were clearly identifiable.

4.4.2.3 Environmental reporting

The Carbon Disclosure Project (CDP; www.cdproject.net) was established in 2000 and provides a secretariat for institutional investors to request information on climate change form the companies in which they invest.

CDP is an international not-for-profit organisation aiming to create a lasting relationship between shareholders and corporations regarding the implications for shareholder value and commercial operations presented by climate change. It seeks information on the business risks and opportunities presented by climate change and greenhouse gas emissions data from the world's largest companies: 3,000 in 2008. Over 8 years CDP has become the gold standard for carbon disclosure methodology and process.

CDP was launched in India in May 2007 as a joint effort of the CII-ITC Centre of Excellence for Sustainable Development and WWF-India. In 2007, CDP-India sent a questionnaire to the 110 largest industries in India and received responses from 39 industries.

Based on these results CII produced a country report ('Carbon Disclosure Project, Report 2007, India'), which is available on CDP's website.

The report provides an analysis on how India's largest companies are responding to climate change. The responses were mixed. Generally, there is an increasing appreciation of the opportunities for a paradigm shift in business models necessitated by climate change. While commercial benefits of engaging in CDM projects have attracted both industry and the financial sector, the benefits of collating and disclosing carbon emissions needs to be further appreciated and applied.

CDP-India will carry out a similar analysis in 2008, doubling the number of questionnaires.

Environmental reporting:

- WRI has made a GHG tool for steel industry; not in the public domain.
- SAIL has used a tool called ECOBILAN; now replaced by GABI.

SAIL is member of the International Iron and Steel Institute, IISI (based in Brussels).
It is very difficult to benchmark environmental performance among steel industries. IISI is therefore in the process of developing common guidelines for delimiting the boundaries of a steel plant, a.o. for GHG reporting. Indian steel plants often have their own power plants, possible oxygen production facilities, and even staff communities within their premises.

4.4.3 The climate change issue

Business risks and opportunities associated with climate change:

- Public concern about the environmental consequences can strengthen the market pressures favouring 'green' companies. This may affect ability to market products and ability to mobilize investments for perceived 'dirty industries'.
- Governmental action to reduce GHG emissions may result in regulatory risk for certain companies.
- Developments in markets, knowledge and technology, may enable industries to cut their carbon emissions, while increasing productivity. New companies may take environmental leadership and may put existing firms in a competitive disadvantageous position.
- If environmental change and degradation were to occur on a large scale, suppliers, employees, operations and customers could all be affected, usually adversely.

The main climate change issue in Indian industries is CDM. Many large companies are state-owned, having longer lead times in developing CDM projects (public procurement procedures etc.).

Therefore, before engaging in a CDM activity, they want to be double certain that the activity is financially attractive and with little risk.

The Federation of Chambers of Commerce and Industries (FICCI) is member of the Ministries Consultative Team on Climate Change. FICCI established its own Task Force on climate change in July 2007, with participation from many industrial sectors. The main activities are to deliberate on policy and regulatory issues. The Task Force produced a "FICCI Climate Change Task Force Report" in December 2007 (only available in hardcopy).

The above-mentioned (paragraph 5.2) CII-ITC Centre of Excellence for Sustainable Development is another industrial initiative addressing climate change issues.

4.4.4 Energy consumption

Over the past decade, energy efficiency in Indian industry has increased steadily. In the major energy-consuming industrial sectors, such as cement, steel, aluminium, fertilizers, etc., average specific energy consumption has been declining because of energy conservation in existing units, and (much more) due to new capacity addition with state-of-the-art technology. In almost every industrial sector, some of the world's most energy-efficient units are located in India (ref. 3).
In most industrial sectors, India has a very broad band (in terms of efficiency), from world no. 1 to very poor performing industries. National-level technology transfer has functioned well in the cement industry, but it does not happen in pulp & paper.

The Indian cement industry is fairly new. The average performance is better than the German cement industry, when several old plants still are in operation.

4.5 SMALL-SCALE INDUSTRIES

Small-scale industries (SMEs) account for about 20% of total industrial energy consumption and 70% of industrial pollution, and until now most efforts have been concentrated on large-scale industries. Thus, there is a huge potential for environmental improvements in SME sectors.

The ECOPROFIT programme (www.ecoprofit.org) promotes environment-friendly technologies in SMEs by:

- Enhancing efficiency of companies
- Reducing demands of raw materials and energy
- Minimising environmental impacts

The programme was initially (since 1991) funded by the European Commission and the Austrian Federal Ministry for Transport, Innovation and Technology. From June 2005 the programme has been funded by GTZ[29]. The programme, which is international, was introduced in India in 2002.

The primary reason for the success of this programme is that it combines economic benefits for the SMEs with environmental benefits.

Sometimes, projects are bundled into one CDM project. The scope of applying the CDM programmatic approach is presently being investigated.

4.6 ECONOMIC DEVELOPMENT

It is necessary to take a comprehensive view of the effects of climate change policies on economic growth and employment to adequately determine the net benefits. Studies on the indirect economic effects of mitigation policies show that they can create jobs. This is plausible considering that energy efficiency investments increase the marginal benefits of capital and/or energy. This means that energy efficiency improvements could create new jobs by using domestically produced energy-efficient technologies and services to replace imported energy.

4.6.1 Technology development

The Prime Minister of India, Dr. Manmohan Singh, has often stressed the importance of improving technology transfer as a key means to address climate change. In the words of the Joint Position

[29] GTZ-Advisory Services in Environmental Management (www.asemindia.com).

Paper of Brazil, China, India, Mexico and South Africa participating in the G8 Heiligendamm Summit, June 2007:

> *"In order for developing countries to contribute to the efforts to address climate change, access to adequate technology is a key enabling condition. We need an agreement on transfer of technologies at affordable costs for accelerated mitigation efforts in developing countries, inter alia through increased use of renewable energy, including biofuels, and enhanced energy efficiency. Rewards for innovators needs to be balanced with common good for humankind. We also consider it necessary and important to enhance developing countries' capacities to deploy mitigation and adaptation technologies."*

Climate mitigation projects, as CDM projects, often induce introduction and dissemination of new technologies, as well as international funding, which may lead to energy conservation and efficient use of resources (human and financial), and thus contribute to sustainable development.

Some Indian experiences and views on technology transfer:

- Confederation of Indian Industries (CII): The protection of intellectual property rights is the main reason for foreign companies being hesitant in technology transfer. Reasons for Indian companies being hesitant are cost and a general risk-adverse culture; advanced technologies often require large investments. Also the investments may not be competitive, and high-risk (venture) capital is scarce and difficult to access.
- In most industrial sectors, India has a very broad band (in terms of efficiency), from world no. 1 to very poor performing industries. Therefore, state-of-the-art technologies have already been transferred or developed in India, and there is not much need for cross-boundary transfer. National-level technology transfer has functioned well in the cement industry.
- The CenPEEP programme (rehabilitation of existing thermal power plants; cf. paragraph 4.1) has worked perfectly in terms of technology transfer.
- India is currently giving high priority to establishing supercritical thermal power plants. For this, Indian manufacturers need capacities in producing the necessary equipment (e.g. high-temperature boilers), while Indian utilities need capacity in commissioning such power plants. In both cases, considerable barriers for technology transfer exist.
- Greenpeace: The Montreal Protocol has a technology transfer mechanism that has proven to work. Why can the same mechanism not be used in climate change?

4.7 THE COST OF INACTION

All global regions will have to face serious impacts on their ecosystems and economies. Impacts on weather will include higher maximum temperatures, more heat waves, increased summer drying with the risk of drought, or increase in tropical cyclone peak wind intensities and more intense precipitation events.

These impacts will have serious economic implications, such as:

- Impacts of sea level rise, including the loss of coastal land/wetlands and the increased costs of sea level protection.
- Impacts from extreme weather: Storms, drought and flooding will increase infrastructure costs.
- Impacts on agriculture: Crop yields will decrease as mean and peak precipitation increases. Agricultural and rangeland productivity will suffer in drought- and flood-prone regions. Damage to a number of crops will increase, as will the risk of forest fire. Changes in monsoon behaviour will seriously impact farming in tropical countries.
- Impacts on buildings and infrastructure: Ground shrinkage could damage building foundations.
- Impacts on commercial activities: There will be shifts in tourist destinations.
- Impacts on energy supply: There will also be less hydro-power potential in drought-prone regions.
- Impacts on energy use: Demand for electric cooling will increase.
- Impacts on water resources, water supply and water quality: There will be less of it and quality will decline.
- Impacts on eco-systems (loss of productivity and bio-diversity).
- Impacts on human health from cold and heat.

- Impacts on human health from disease, secondary effects.
- Socially contingent effects (arising from multiple stresses and leading to migration, famine, etc).

Thus, for every nation there will be substantial costs from inadequate measures to meet the challenges of climate change. The British "Stern Review: The Economics of Climate Change" (2007) is so far the most comprehensive approach to evaluate these costs at a global scale. The Team of the present study has not come across any similar studies assessing the impacts for India.

4.8 CONCLUSIONS AND RECOMMENDATIONS

Although there is increasing awareness and pressure to address climate change, focus in India is still on other priorities such as economic growth, electricity access, air quality management and energy security.

The Government's approach is to integrate climate change concerns in sustainable development. Instead of focusing on climate change as a driver, India's development partners should therefore mainstream climate change into development cooperation projects, research projects and other activities, and link more directly to the real drivers in policy development; e.g. economic growth, urban development, and poverty eradication.

Similarly, the co-benefits approach for India should not be climate-centric, rather energy-security centric (for Government), energy-efficiency centric (for industries) and air-quality centric (for the general public). Generally, GHG mitigation is not perceived a co-benefit, only an ancillary benefit from pursuing other – more high priority – policy objectives.

The present study has focussed on big industries and power plants, but it may be the transportation sector, which offers the greatest opportunity for human health improvements and greenhouse gas reductions. Also, an often overlooked environmental impact is the detrimental effects of surface ozone on agricultural productivity. In terms of national economy, this may be the most severe pollutant.

The EC-funded GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) project is probably the most comprehensive attempt to estimate the co-benefits of improved air quality and greenhouse gas mitigation for India.

Substantial mitigation cost savings and socio-economic benefits from applying cost-effective end-of-pipe measures and structural changes to reduce air pollution. By 2020 the years of life lost can be reduced to half, compared with maintaining current legislation, with a slight increase in control costs (from about 0.7% to about 0.8% of GDP). These measures lead, as a co-benefit, to lower CO_2 emissions, which in 2020 will be reduced from about 320% to about 280% of current emissions.

The GAINS project and its results are little known outside a few academic institutions, and it is therefore recommended that the project outcome be disseminated widely, not the least to policy makers and public authorities.

4.9 REFERENCES

1. "Limiting Global Climate Change to 2^{o} Celcius: The way ahead for 2020 and beyond". European Commission Communication (COM(2007) 2), 10 January 2007.
2. "Winning the battle against global climate change", European Commission staff working paper, February 2005.
3. "India: Addressing Energy Security and Climate Change". Ministry of Environment & Forests and Ministry of Power (Bureau of Energy Efficiency), October 2007.
4. Maurizio Bussolo and David O'Connor: "Clearing the Air in India: The economics of climate policy with ancillary benefits". Working Paper No. 182, OECD Development Centre, November, 2001.
5. M.L. Mittal et el : "Surface Ozone in the Indian Region". Undated paper.
6. "Integrated Environmntal Strategies (IES) Study for City of Hyderabad, India". Prepared by the Environment Protection Training and Research Institute (EPTRI), April 2005.
7. Kristin Aunan et al: "Climate change and air quality – measures with co-benefits in China", Environmental Science and technology, 15 August 2006, pp. 4822-4829.

8. Haakon Vennemo et al: ”Benefits and costs to China of joining a climate treaty”, Working Paper 2007-004, Econ, 14 December 2007.
9. Kristin Aunan et al: ”Benefits and costs to China of a climate policy”. Environment and Development Economic, No. 12, 2007, pp. 471–497.
10. Lin Gan and Juan Yu: “Bioenergy transition in rural China: Policy options and co-benefits”. Energy Policy, February 2008, pp. 531-540.
11. T.K. Mandal et al: ”Observation of Ozone, Trace Gases, UV radiation, TSP and Aerosol, its composition and Optical Depth at Darjeeling (27.01^{0}N, 88^{0} 15"E, msl=7204 feet) and associated places”, undated paper, National Physical Laboratory, New Delhi.

5. PILOT PROJECT

5.1 PROJECT IDEAS

5.1.1 World-class air pollution and climate change modelling

Background

For the purpose of simulating and analyzing air pollution and greenhouse gasses in the Indian context, one can essentially distinguish between air quality models and climate change models[30].

Air quality
Most air quality models (AQM) used in India have been made available by US EPA, although some European models are also used. The 'source code' is not available for most of these models, and they have not been customized to Indian conditions (e.g. meteorological and traffic configurations). There are therefore many situations, where these 'black-box' models are of limited or no value as their predictions are highly conservative. Indian researchers need be capable of amending imported models and in particular of developing own models of high quality, which may suit to required conditions of meteorology, traffic and biomass use as fuels, particularly in urban – poor dwellings and thus contributing to climate change effects.

Climate change
A main concern in India is the impact of climate change on monsoon behavior. Most global models do not address this aspect, and there is a strong need to develop regional climate change models.
For such purposes high-resolution (e.g. 1.0^o or 0.5^o by longitude and latitude) regional circulation models are needed, including long-distance transport and atmospheric chemistry. To develop such models, enhanced cooperation with European institutions could be instrumental.

Data generation
Currently, the most critical part for generating reliable results from computer modeling in India is inadequate emission inventories. There is substantial potential for improving the national inventories, and inventories at state level are either weak or non-existing. Good state-level inventories will, besides providing data for analyses, improve the basis for enforcement of environmental regulations and for development of appropriate state policies.

Objectives

The overall objective of the proposed project is to strengthen Indian participation in the development of state-of-the-art air pollution and climate models. This will be achieved by conducting 6 work packages:

1. Increasing capacities in measurements/monitoring and emission inventories;
2. Increasing capacities and synergies in air quality modelling;
3. Facilitating the development of regional chemistry-transport models;
4. Facilitating integration of the various disciplines within air pollution measurement and modelling;
5. Supporting stronger participation in pertinent international activities;
6. Enhancing capacities in forecasting air pollution and impacts; and
7. Cross-cutting issues.

Work Package 1 - Increasing capacities in measurements/monitoring and emission inventories

The West Bengal Pollution Control Board (WBPCB) has mentioned that both generation and compilation of data need be improved. As capacity development is the key issue, an appropriate way of supporting this would be through twinning with European agencies with similar responsibilities.

[30] Climate models can be roughly categorized according to time horizon: Short-term (e.g. weather forecasting), seasonal (e.g. monsoon prediction) and long-term (climate change). As the former two are beyond the scope of the present study, the term 'climate change models' shall be used for clarity.

WBPCB also mentioned that the increasing pressure from preparing the UNFCCC national communications may soon imply that GHGs need be included in state emission inventories.

Part of improving emission inventories is to improve monitoring. Indian stakeholders have expressed needs to improve capacities in continuous measurements, optimal location of monitoring stations, the use of innovative methods and advanced instruments for air quality measurements, and impact measurements (e.g. ozone on agriculture). It has also been suggested to put in place a measurement infrastructure (e.g. creation of a centralized and/or regionalized ambient air quality data bank) with focus on transparency, standardisation of techniques (in data generation, recording, collation, quality control etc.) and on-line availability.

It is recommended to monitor a limited, defined set of health relevant air quality parameters. The EU has set air quality standards that are aimed at preventing harmful effects to human beings and ecosystems and which may be used as valid inspiration (http://ec.europa.eu/environment/air/quality/standards.htm).

Furthermore, it has been mentioned that measurement equipment is often not calibrated and maintained properly, thus hampering data quality. There is a strong need for mechanisms ensuring more reliable data. One means may be to have more equipment manufactured in India, for easy of after-sales services and spare-parts and for lower costs.

Work Package 2 - Increasing capacities and synergies in air quality modelling

Many stakeholders have stated that air quality modelling (AQM) capacities need be strengthened - in several aspects:

a) More of the same kind: As one example, the Industrial Source Complex model (ISCST) developed by US EPA is widely used in India for dispersion modelling at local/episodic, urban and regional scales. However, this is almost the only model used, and there is a need to be more acquainted with other available dispersion models, to enable benchmarking of the pros and cons of various approaches, and thus become in a better position to further develop and eventually tailor/customize such models suitable to Indian conditions.
b) Introduction of new types: State-of-the-art models used in e.g. Europe, but still not in India, need be transferred to India through joint projects and training.
c) Enhanced model building capacity: Indian scientists should participate on equal footing with international model developers in improving existing models and developing new models. This can be done through joint projects, twinning, exchange of experts etc.
d) Develop a protocol for monitoring and modelling of Indoor Air Quality (IAQ) in naturally and Heating, Ventilated, Air conditioned (HVAC) buildings in urban areas with a view to develop National guidelines for indoor concentrations of air pollutant particularly associated with climate change, e.g. CO_2 emissions in urban-poor dwellings due to burning of biomass fuels, and emissions of CFCs and certain hydrocarbons in urban modern buildings.

Cooperation between Indian and European researchers could provide substantial mutual benefits. Indian researchers could enhance their capabilities of developing own models and eventually end up with open-source state-of-the-art models. European researchers would benefit from testing and amending own models for Indian conditions and from scientific results of Indian researchers.

Work Package 3 - Facilitating the development of regional chemistry-transport models

The climate change modeling community in India is very small, primarily conducted by the Indian Institute of Tropical Meteorology (IITM) under the new Ministry of Earth Sciences (MoES). MoES has recently decided to set up a Centre for Climate Change Research (CCCR) at IITM as part of a larger national Program on Global and Regional Climate Change.

IITM has long been part of the international climate modeling community and has therefore built an extensive modeling capacity. Thus, the source codes and other details of models used at IITM are all known to the researchers.

IITM is already working with the Max-Planck-Institut für Meteorologie, Hamburg, Germany, using an existing chemistry-transport-model (Model of Ozone and Related Tracers, MOZART). However, the resolution of this model (1.8^o by 1.8^o) is too coarse for regional modelling.

Work Package 4 - Facilitating integration of the various disciplines within air pollution measurement and modelling

As an example, the current network of CPCB is focussing on urban PM10 and cannot answer many questions regarding aerosol and ozone. Further, no definite answers are available related to various sources of ambient pollutants (source apportionment), emission factors of pollutants generated from different sources and availability of the short term ambient concentrations of criteria pollutants required for the formulation of dispersion models. Besides, CPCB also does not have data on source profiling required for the source – receptor modelling which is required for ultimate formulation of health based ambient air quality standards. At the source levels too, looking at the current pace of industrialization, the existing source standards of air pollutants also need to be 'emission based' rather than 'ambient based'. It will ensure an effective control on emissions of hazardous pollutants from various industries.

The European EUSAAR concept (http://www.eusaar.net/) may be an appropriate model of organising such an effort. The objective of EUSAAR (European Supersites for Atmospheric Aerosol Research) is the integration of measurements of atmospheric aerosol properties performed in a distributed network of 20 high quality European ground-based stations. This integration contributes to a sustainable reliable operational service in support of policy issues on air quality, long-range transport of pollutants and climate change.

The EUSAAR project comprises:

- Networking activities to provide easy access to high quality data bases and promote standardised measurement/monitoring protocols, inter-comparability of observations and quality assurance common to all research sites.
- Joint research activities aimed at developing future tools for aerosol monitoring and dissemination of information. These developments can only be achieved through coordinated research projects sharing experience, know-how and human capital, as offered by the proposed infrastructure.
- Joint research activities aimed at developing/formulating/validating 'episodic', 'local' and 'urban' AQMs; assessment of atmospheric CO_2 concentrations in urban/metropolitan areas to study the phenomenon of 'urban CO_2 Dome'; validating and testing the present available US EPA and/or European AQMs for Indian urban conditions; identification of sources of urban air pollutants (source apportionment); preparing source profiles in urban areas for source-receptor based modelling for exposure studies; preparing detailed emission inventories and emission factors; and formulate strategies for using remote sensing based measurement/monitoring techniques for ambient air pollutants.
- Creation of a centralized/regionalized ambient air quality/meteorological data bank accessible on line to all those researchers/scientists working in air quality modelling.
- Joint research activities in developing monitoring/modelling capabilities in predicting the indoor air pollutants contributing to climate change in naturally and HVAC buildings in urban areas; formulating guidelines for indoor air pollutants of concern which may further be used for formulating the standards for different kinds of buildings.
- Promotion of scientific excellence (mobility of experts) and access of research scientists, in particular inexperienced users, to the high quality EUSAAR infrastructures (supersites) in order to conduct advanced research in environmental sciences such as atmospheric dynamics, cloud microphysics, atmospheric chemistry, climate studies, remote sensing atmosphere, atmospheric radiative transfer.
- Training courses.

Two European Networks dealing with Air Pollution Measurements (AQUILA http://ies.jrc.cec.eu.int/Units/eh/Projects/Aquila/) and Air Quality Modelling (FAIRMODE http://pandora.meng.auth.gr/modnet/) could also serve as models on facilitating integration and data harmonization. The Networks are a platform for the correct implementation of EU air quality legislation, information exchange among the members and creation of common projects for research and validation purposes.

Work Package 5 - Supporting stronger participation in pertinent international activities

Indian scientists may gain substantial benefits from increased active participation in international cooperation programmes. At the same time the international R&D community may benefit from Indian research activities. This may be supported by offering travel grants to participating Indian scientist. Two examples are:

A. The Task Force on Hemispheric Transport of Air Pollution (HTAP, http://www.htap.org/) analyses air pollutants, which are transported on an intercontinental scale, in order to better understand air pollution problems in population centres and impacts on remote areas. HTAP, which is funded by UNECE[31], could in the next phase (after 2009) include India. HTAP has actually been preparing for this by explicitly looking at India. Indian scientists have also participated in some activities.

   Observations and model predictions show the significance of intercontinental transport of ozone and its precursors, fine particles, acidifying substances, mercury, and persistent organic pollutants. In its first report[32] HTAP concluded that 'intercontinental transport can have small yet significant effects on surface concentrations'.

B. MICS-Asia (http://www.adorc.gr.jp/adorc/mics.html) is a Model Inter-Comparison Study on transport and deposition of sulphur, nitrogen compounds, ozone and aerosols in East Asia. It has been going on for more than 10 years, with annual meetings organized at IIASA (International Institute for Applied Systems Analysis), Austria. Currently, the following Asian countries are participating: China, Japan, Korea, and Thailand.

Work Package 6 - Enhancing capacities in forecasting air pollution and impacts

This would include economic consequences and climate change, thereby improving the basis for air pollution control policies and strategies.

India has participated in the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)-Model (www.iiasa.ac.at/web-apps/apd/gains/), which was recently completed (Indian focal point: The Energy and Resources Institute; TERI).

The GAINS Model integrates several features[33]:

- Economic Activity Pathways; activities causing emissions (energy production and consumption, passenger & freight transport, industrial and agricultural activities, solvent use, etc.);
- Emission Control Strategies; the evolution of emissions and control over a given time horizon ;
- Emissions Scenarios; emissions are computed for a selected emissions scenario (combination of energy pathway and emissions control strategy), emission factors, results displays, and input values are also available under this action;
- Emission Control Costs; displays emission control costs computed for a selected emissions scenario;

[31] HTAP was established in 2004 as a Task Force of the UNECE (United Nations Economic Commission for Europe) Convention on Long-range Transboundary Air Pollution. The Convention currently has 51 Parties, covering almost all of Europe and North America and extending into Central Asia. All countries on the Northern Hemisphere have now been invited to join the Convention.

[32] "Hemispheric Transport of Air Pollution 2007", Air Pollution Studies No. 16, United Nations Economic Commission for Europe, New York and Geneva, 2007.

[33] Pollutants: Ammonia (NH_3), Carbon dioxide (CO_2), Methane (CH_4), Nitrogen oxides (NO_x), Nitrous oxide (N_2O), Suspended particulate matter (SPM), Respirable particulate matter (RPM, e.g. PM10, PM2.5 and PM1), Sulphur dioxide (SO_2), Carbon Monoxide (CO), Ozone (O3), Hydrocarbon (HC), and Volatile organic compounds (VOC).

- Impacts; presents ecosystem sensitivities and human health impacts of air pollution in ambient as well as indoors;
- Data Management; provides an interactive interface, where owner-specific data can be modified, updated, exported, and downloaded.

Thus, GAINS can be used as a very strong tool in support of air pollution control policies and strategies. This could be demonstrated during the new project - at national and state level - by anchoring the model at various authorities and institutions. To enhance Indian modelling capacities, similar models could also be developed or tailored to Indian conditions.

Work Package 7 – Cross-cutting issues

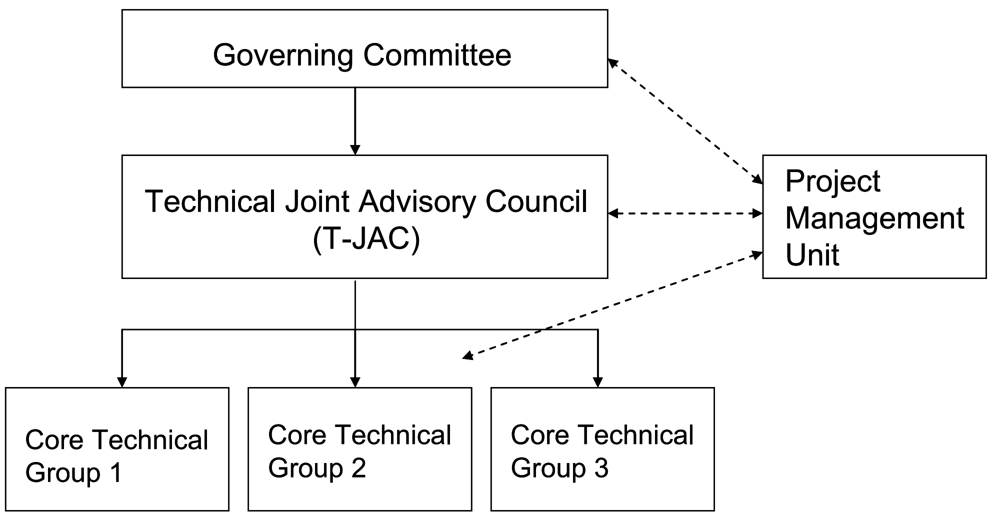
To further develop the issues of the other six work packages, the following cross-cutting activities may be instrumental:

1. Allowing European professors to teach 1-2 months specific courses at selected universities, by regularly organizing summer-schools in India on e.g. modeling or measurement issues with reknowned teachers.
2. To offer to Indian students/scientist scholarships in reknowned European institutions to work on modeling/measurement techniques to be applied later on in India.
3. To endorse measurement harmonization exercises, where European scientist could provide guidance.
4. To consistently use the results of such projects in policy context such that also in India these activities will be more requested.
5. Supported projects should stimulate interdiciplenary collaborations.

Implementation modalities

Organisation of the programme:

1. Governing Committee, chaired by e.g. MoEF/CPCB; representatives from Government (MoEF, MoES, MoST), European-Commission, academia in India and EU, and other pertinent stakeholders.
2. Technical Joint Advisory Council (T-JAC), covering all aspects, i.e. measurements, inventories, air quality modelling and climate change modelling. Representatives from the academia (model developers and users); 4-5 representatives from India and 4-5 representatives from EU. T-JAC defines projects (e.g. models to be developed) to be conducted by selected members of the R&D community.
3. Core Technical Groups. These groups will consist of various researchers in different selected areas each coordinated by two T-JAC members (one from India and one from EU) in a particular area of specialization.
4. Programme Management Unit located in one of Indian institutions: Responsible for day-to-day management and coordination of activities.



Potential Indian participants are:

Central Pollution Control Board (CPCB) Laboratory	Mr. Prashant Gargava, Env. Engineer (air pollution models), Eepg.cpcb@nic.in; tel. 011-22308902	Monitoring and dispersion modelling of PM
National Physics Laboratory (NPL), Delhi.	Dr. M.K. Tiwari (mktiwari@mail.nplindia.ernet.in).	Measurements and modelling in trace gasses, aerosols, radiation. Emissions inventory. Quality control & assurance
Indian Institute of Tropical Meteorology (IITM), Pune	Dr. Gufran Beig; beig@tropmet.res.in Dr. K. Krishna Kumar; Krishna@tropmet.res.in	Global and regional climate change modelling, emission inventories
Indian Institute of Technology (IIT) Delhi, Department of Civil Engineering	Prof. Mukesh Khare (kharemukesh@hotmail.com)	Urban and vehicle models; dispersion modelling and indoor air pollution
The Energy and Resource Institute (TERI)	Ms. Ritu Mathur, tel. +91-11-24682100; ritum@teri.res.in	Emission control strategies (e.g. GAINS)
Advisory Services in Environmental Management (ASEM India; MoEF + GTZ; www.asemindia.com)	Dr. A.L. Aggarwal (alaggarwal@senesindia.com; Tel 09312274668)	
Physical Research Laboratory, Ahmedabad	Dr. Shyam Lal (shyam@prl.res.in)	Modelling (global, regional); measurements PM, chemical characterisation, O3, NOx
Indian Institute of Technology (IIT) Madras	Dr. S M Shiva Nagendra (shivanagendra@yahoo.com)	Urban air quality; vehicular air pollution; source apportionment
Indian Institute of Technology (IIT) Bombay, Department of Chemical Engineering	Dr. Chandra Venkataraman (Chandra@che.iitb.ac.in)	Emissions inventories
Indian Institute of Technology (IIT) Kanpur	Dr. Mukesh Sharma (mukesh@iitka.ac.in)	Measurements PM
Indian Institute of Technology (IIT) Roorkee, Dept. Civil Engineering	Dr. B.R. Gurjar bholafce@iitr.ernet.in	Emissions from vehicles
Dayalbagh Educational Institute (Deemed University), Agra	Dr. Ranjit Kumar (rkschem@rediffmail.com)	Measurements PM, chemical characterisation
ISRO Space Applications Centre (SAC), Ahmedabad	Dr. Kiran Kumar (kiran@sac.ernet.in)	Space instrumentation for probing the lower atmosphere
National Environmental Engineering Research Institute (NEERI)	Mr. George Varghese Scientist E1 (kv_george@neeri.res.in)	Air Pollution; US EPA models and their use in Indian conditions; Pollution rose diagrams
Winrock International India, Delhi	Ms Sumana Bhattacharya, sumana@winrockindia.org; tel +91-11-260013876	Impacts, emission inventory (UNFCCC NatCom)
IARA		Agriculture / climate
Centre for Development of Advanced Computing (C-DAC), Bangalore		Modelling – in gasses - local /regional
National Atmospheric		

Research Laboratory (NARL); Andhra Pradesh		
SPL		
Indian Institute of Science (IISC), Bangalore		Climate/aerosol/radiation
NDL		Gas/aerosol/radiation
Physical Research Laboratory (PRL), Ahmedabad		Gas
Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Bangalore		Climate/gasses
Indian Agricultural Research Institute (IARI)		
NCMRWF		

5.1.2 Greenhouse gas emission factors at iron & steel and cement plants

Background

The Confederation of Indian Industries (CII) has been assigned to prepare the GHG emission inventory estimates from the Industrial process sector under the aegis of India's Second National Communication. They plan to go further along Tier 1-> Tier 2; primarily disaggregating per industry sectors, possibly sub-sectors and sub-sub-sectors. They entirely base their work on existing information. There may be a need for a coordinated and comprehensive approach towards improving the methodologies through new knowledge.

Within the industrial sector the most dominant sub-sectors were (NatCom 1, 1994 data):

Source of emission	CO2 equivalent (Gg)	Tier used	EF used
Iron and steel production	44445	Tier I	D
Cement production	30767	Tier II	CS
Ammonia production	14395	Tier I	D
Lime stone and dolomite use	5751	Tier I	D
Nitric acid production	2790	Tier II	CS
Lime production	1901	Tier I	D
Ferro alloys production	1295	Tier I	D
Aluminium production	749	Tier I	D
Carbide production	302	Tier I	D
Soda ash use	273	Tier I	D

CS: Country-specific emission factor, D: IPCC default emission factor.

It is suggested that eventual European assistance shall be focussed on those sub-sectors contributing most to the total emission of GHGs, i.e. iron & steel and cement production, as more accurate estimates for these sectors have most significance for India’s total inventory.

India’s Initial National Communication from 2004 contains 47 project proposals for improvements of future National Communications (Table 7.5 (pages 217-221)). The below table shows the proposals pertaining to monitoring of GHGs from iron & steel and cement production. MoEF has recently confirmed that these proposals are still on the ‘wishing-list’.

No	Type / Sector	Title	Description
Uncertainty reduction in inventory estimation			
12	Energy and industrial process	GHG emission measurement from large point sources—steel plants and cement plants	Due to high requirement of coking coal for steel production, the steel sector has very high emissions per unit of production and contributes substantially to Indian CO2 emissions. Similarly cement production contributes significantly to energy and process based CO2 emissions. This project envisages GHG emission measurements from 10 steel plants and 30 cement plants. The process-based emissions will be distinguished and will be measured separately.
17	Industrial Processe s	Reduction of uncertainties in GHG emissions factor in lime and cement sectors in India	This project will help to reduce the uncertainties in CO2 emission coefficients derived for the first phase of NATCOM. The work programme will entail systematic collection of CO2 fluxes, samples of raw materials, intermediate and final products for analysis. About 50 cement plants representing prevalent technologies for producing cement in India will be covered.

India's 2nd National Communication is being prepared; planned for submission in 2011 (base year 2000; it was 1994 in NatCom 1). CII has been tasked to write the chapter on Industrial Processes and Product Use (IPPU) during 2008-2009. They plan to go further along Tier 1-> Tier 2 -> Tier 3; primarily disaggregating per technologies.

In NatCom 1 Industrial Processes was section 2 of the national GHG inventory. The inventory included the following processes (ranked according to GHG volumes; page 36 in NatCom1):

1. Iron and steel production
2. Cement production
3. Ammonia production
4. Limestone and dolomite use
5. Lime production
6. Ferro alloys production
7. Aluminium production
8. Carbide production
9. Soda ash use

IPCC's latest Guideline for National Greenhouse Gas Inventories (2006) divides IPPU into 8 categories (page 1.6):

A. Mineral industry; 5 sub-categories and 4 sub-sub-categories
B. Chemical industry; 10 sub-categories and 10 sub-sub-categories
C. Metal industry; 7 sub-categories
D. Non-energy products from fuels and solvent use; 4 sub-categories
E. Electronics industry; 5 sub-categories
F. Product uses as substitutes for ozone depleting substances; 6 sub-categories and 2 sub-sub-categories
G. Other product manufacture and use; 4 sub-categories and 9 sub-sub-categories
H. Other; 3 sub-categories

<u>Project concept</u>

The overall objective of the proposed project is to improve the GHG emission factors used for India's reporting to UNFCCC (the national communications). The project will focus on two industrial sub-sectors: Iron and steel production and cement production, since these two sub-sectors together account for about 75 % of all CO_2 emissions from industrial processes (Initial National Communication; 1994 data).

Indian and EU industrial sub-sector experts are tasked to jointly develop improved emission factors for India and at the same time suggest cost-effective environmental improvements for specific industries. The manufacturers participating in the project shall, in return for delivering data, receive well-prepared proposals for significant cost-reductions, e.g. through energy and/or raw materials savings.

At the time of the Initial National Communication the Central Institute for Mining & Fuel Research (CIFMR), Dhandbar, Jharkhand, measured the CO_2 emission fluxes from one or two steel plants. However, these were not used for the estimates. Development of new emission factors for iron & steel for the Second National Communication has now been tasked to CIFMR.

For the Initial National Communication the emission factor for cement sub-sector was prepared by the National Chemical Laboratory (NCL), Pune.

On this background, it is suggested that actual measurements and analyses are carried out in twinning arrangements between CIFMR and NCL and similar European institutions or a similar arrangement facilitating exchange of experts and joint projects.

The pertinent national companies and associations could ensure dissemination and facilitate replication of the results within the respective sub-sectors, i.e.:

- Iron and steel production: Steel Authority of India Ltd. (SAIL; www.sail.co.in), Environment Management Division, Delhi. SAIL has its own R&D institution, the R&D Centre for Iron and Steel (RDCIS), but may participate in data generation.
- Cement production: Cement Manufacturers' Association (CMA; www.cmaindia.org), Delhi.

The Confederation of Indian Industries (CII) has been tasked to write the National Communication chapter on Industrial Processes and Product Use during 2008-2009. Thus, CII will ensure the use of data in the National Communication.

Approach:

1. A small number of representative manufacturers within each industrial sub-sector is selected. The manufacturers should be grouped according to technology or energy/environmental performance (e.g. state-of-the-art, average, below average).
2. Data collection is conducted at each industry to arrive at plant-specific emission factors. Direct measurements from stacks may be needed.
3. The plant-specific emissions are benchmarked nationally and internationally, and suggestions to improve the environmental performance are elaborated. Focus shall be on initiatives, which are cost-effective and attractive to the specific industries.
4. The plant-specific emission factors are used to develop national default values, possibly technology-specific.

For cement manufacturing there should be a specific interaction between Indian and EU stakeholders (through scholarships etc.) regarding the use of hazardous wastes as a resource for cement production. EU guidelines in this regard may be adopted in India.

EU experts could also assist in conducting peer reviews of emission factors for other sectors. This has been suggested by the National Physics Laboratory. Such peer reviews would reveal eventual needs for further technical assistance.

The development of the updated emission factors shall comply with the latest IPCC Guidelines[34].
The European guidelines for the monitoring and reporting of greenhouse gas emissions and the way these are applied in the European Emissions Trading System (ETS), may be used as point-of-departure for determining the emission factors. The ETS guidelines are in accordance with the IPCC guidelines.

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[34] "2006 IPCC Guidelines for National Greenhouse Gas Inventories", Volume 3: "Industrial Processes and Product Use".

ETS guidelines on production of pig iron and steel including continuous casting

The guidelines refer in particular to primary (blast furnace (BF) and basic oxygen furnace (BOF)) and secondary (electric arc furnace (EAF)) steel production.

CO_2 emissions result from the following emission sources and source streams: Raw materials (calcination of limestone, dolomite and carbonatic iron ores, e.g. $FeCO_3$); conventional fuels (natural gas, coal and coke); reducing agents (coke, coal, plastics, etc.); process gases (coke oven gas (COG), blast furnace gas (BFG) and basic oxygen furnace gas (BOFG)); consumption of graphite electrodes; other fuels; and waste gas scrubbing.

In case the installation for the production of pig iron and steel is part of an integrated steelworks, emissions may be calculated in two different ways:

(a) For the integrated steelworks as a whole, using the mass-balance approach.
The mass-balance approach shall consider all carbon in inputs, stocks, products and other exports from the installation to determine the level of emissions of greenhouse gases over the reporting period, using the following equation:
CO_2 emissions = (input - products - export - stock changes) * conversion factor CO_2/C.

(b) The installation for the production of pig iron and steel as individual activities of the integrated steelworks. The guidelines differ between two emission sources:
1) CO_2 emissions from combustion installations and processes, i.e. processes where fuels are not used as reducing agents. Emissions are calculated by multiplying the net energy content of the fuel consumed with emission factors and oxidation factors.
2) Process related CO_2 emissions. Total CO_2 emissions are calculated as follows:
CO_2 emission = Σ (activity data$_{INPUT}$ * emission factor$_{INPUT}$) - Σ (activity data$_{OUTPUT}$ * emission factor$_{OUTPUT}$),
where activity data are mass flows multiplied with net calorific values and emission factors are reference data given by the guideline.

ETS guidelines on production of cement clinker

The guidelines differ between two emission sources:

CO2 emissions from combustion installations and processes (Annex II):
This comprises boilers, burners, kilns, incinerators, engines, dryers, flares etc.
Emissions are calculated by multiplying the net energy content of the fuel consumed with emission factors and oxidation factors.

Process related CO2 emissions (Annex VII):

1. From calcination of carbonates in the raw materials used to produce the clinker. Emissions are calculated based on the carbonate content of the process input or on the amount of clinker produced.
2. From partial or full calcination of cement kiln dust or bypass dust removed from the process.
3. In some instances from the non-carbonate carbon content in limestone, shale or alternative raw materials (e.g. fly ash) used in the raw meal in the kiln.

In all cases, emissions are calculated by multiplying activity data with emission factors.

5.2 RECOMMENDED WAY FORWARD

The further development and maturing of the two selected pilot projects will depend much on which instrument(s) to fund the activities.

The modelling project is to a large extent a research cooperation project, and it may therefore be appropriate for FP7 support. If it is agreed to follow this route, a brief topic description may be included in a forthcoming draft annual work programme for Cooperation Theme 6 - Environment (incl. Climate Change). This draft shall go through the usual approval procedures, by the Programme Committee etc., and then the topic can be included in a call for proposals.

This way, the project description shall be much shorter than presented in this document, and thus the details of the project cannot be predetermined to the same extent as with a Terms of Reference of a Project Document.

The Team has not investigated the possibility for Indian co-finance, e.g. through the climate change funds managed by the Ministry of Earth Sciences.

According to the Team's knowledge there is no immediate funding mechanism suitable for the other selected project, the GHG emission factors. Also, it is assumed that the project is too big to be implemented as part of an existing framework contract.

It is therefore essential – as one of the first activities – to identify possibly funding options, as the remaining procedural steps would depend much on how the project is conceived funded. The next step would be to formulate a process action plan. For inspiration, such a plan may include the following steps:

DEADLINE	ACTIVITY	MANAGEMENT RESPONSIBILITY
	Identification of appropriate funding instrument(s)	RELEX, ENV and ENTERPRISE
	Indicative budgets	
	Presentation and discussion of project concept with the Ministry of Environment and Forests	EC Delegation, Delhi
	Formulation mission. Draft ToR, finalise ToR, selecting and contracting consultant. Key output will be a draft project/programme description (possibly a ToR), including organisation, budget etc.	
	Commenting period	EC and GoI
	Appraisal?	
	Final project/programme document.	
	Approval by management or finance committee	EC funding agency
	Approval by GoI.	
	Signing of Government agreement	GoI + EC
	Project/programme is tendered according to the rules of the funding agency.	
	Project/programme consortium selected and contracted.	
	Set-up project/programme steering committee.	
	Project/programme mobilisation.	

6. PERCEPTIONS AND EXPECTATIONS OF EU-INDIA COOPERATION IN CLIMATE CHANGE

6.1 CURRENT COOPERATION ACTIVITIES

6.1.1 EU-India Initiative on Clean Development and Climate Change

The EU-India Summit in New Delhi, 7 September 2005, agreed to establish the "India-EU Strategic Partnership - Joint Action Plan", (http://ec.europa.eu/external_relations/india/sum09_05/index.htm).

As part of this Action Plan, the parties agreed (page 13) to launch an "EU-India Initiative on Clean Development and Climate Change". The Initiative will focus on voluntary practical measures, and will be taken forward at successive EU-India summits. In view of the particular importance of cleaner technologies for tackling climate change, both sides further agreed to:

- Identify and develop ways of widening access and overcoming the barriers to dissemination of such technologies in India and the EU and more widely;
- Increase funding and promote public-private partnerships for research and development of cleaner technologies;
- Promote adaptive research and development to suit the resource endowment of both parties;
- Reduce the price gap between "cleaner" and "less efficient" technologies by seeking economies of scale;
- Hold experts' meetings on climate change, including on the Clean Development Mechanism (CDM) in 2005.

6.1.2 Cooperation in climate change research

The "1st EU-India Strategic Science and Technology Workshop on Climate change research needs" was conducted 8-9 February 2007 in Delhi. The workshop identified several topics and future research needs that are of common interest to both European and Indian scientists.

The first project was announced by the FP7 2008 2nd call:

Area:	6.1.1.6: Response strategies: Adaptation, mitigation and strategies.
Topic:	ENV.2008.1.1.6.1: Impacts on Himalayan glaciers retreat and monsoon pattern change on the water resources in Northern India, and adaptation strategies. Deadline 25 February 2008.

FP7 funds around 3.5 M€, including Member States' contributions possibly +4 M€. Project proposals are presently evaluated. Expected project launch early 2009.

A follow-up workshop was organized in Delhi in early March 2008 to discuss what more to do after 2009, when the first project is running. At present, no specific calls are planned.

In the FP7 2007 call there was a topic on air pollution in megacities:

Activity:	6.1: Climate change, pollution and risks.
Topic:	ENV.2007.6.1.1.1: Megacities, air quality and climate (regional and global scale; mitigation options).

A project has been approved, but contract negotiations are still on-going (may be completed September 2008). This project may include an Indian city.

6.1.3 India-EU Energy Panel

http://ec.europa.eu/dgs/energy_transport/international/bilateral/india/energy/

At the fifth EU-India Summit of 8 November 2004 the political decision was taken to embark in an energy dialogue. Key priorities for our cooperation are development of clean coal technologies, increasing energy efficiency and savings, promoting environment friendly energies as well as assisting India in energy market reforms.

The India-EU Energy Panel has been created as the formal instrument of EU-India cooperation in the energy sector and its constitutive meeting was held in June 2005. Four working groups were established.

The Panel has held three meetings: June 2005, 7 April 2006 (New Delhi), and 20 June 2007 (Brussels).

Under the umbrella of the Energy Panel, four working groups have been created:
1. Renewable energy/energy efficiency,
2. Coal/clean coal technology,
3. Fusion/India's participation in the ITER project and
4. Petroleum/natural gas.

Four concrete studies in the sectors of coal/clean coal and energy efficiency/renewable energy are planned to be financed by the European Commission's 'EU-India Action Plan Support Facility'. The Support Facility, which is still in the preparation phase, has five areas, one is climate change.

Work Group on coal/clean coal technology
Co-chairs:
Mr Rajiv Sharma, Joint Secretary, Ministry of Coal; Dirtech.moc@nic.in
Mr Derek Taylor, DG TREN; Dereck.taylor@ec.europa.eu

Meetings: 22 March 2006 (India); 28-29 November 2006 (EU); 21-22 January 2008 (Delhi). 17-20 June 2008 (Brussels; incl. a site visit to lignite production and power generation in Poland).

At its first meeting, the work group identified 10 'thrust areas for research activities', most of them being within mining methods. One area is pertaining to the present study: 'Application of IGCC technology with high ash coal'.

The third meeting was originally arranged for 30 May 2007 in India, but was cancelled. An informal meeting between the two co-chairs agreed to enlarge the scope to include the entire value chain from mining to power generation. Part of this decision was to split the Work Group into two Work Groups, one on coal (primarily mining) and one on clean coal (primarily electricity generation).

Other Work Groups
The activities of the other Work Groups do not pertain to the current study.

6.1.4 Other pertinent events

1st EU-India Industrial Conference on Energy held in New Delhi, April 2006.

Asia-Europe Climate Challenge Dialogue, Helsinki, Finland, 7 September 2006.

ASEM 6: Cooperation on climate change, 10-11 September 2006

The EU-India Summit: The previous one was the eighth in Delhi, 30 November 2007 (dominated by climate change and trade issues).

6.2 PERTINENT PROJECTS

GAINS-Asia
Greenhouse Gas and Air Pollution Interactions and Synergies – Asia; www.iiasa.ac.at/web-apps/apd/gains/

The GAINS-Asia project has brought together a multinational team of experts, who has developed a state-of-the-art disciplinary model to assess the co-benefits of air pollution and greenhouse gas emission reductions. A special analysis has been made for India. The Indian Focal Point has been The Energy and Resources Institute (TERI).

The GAINS Model simultaneously addresses health and ecosystem impacts of particulate pollution, acidification, eutrophication and tropospheric (ground level) ozone. Simultaneously, the GAINS Model considers greenhouse gas emission rates and the associated value per ton of CO_2 equivalence. The

GAINS Model assesses emissions on a medium-term time horizon, emission projections are specified in five year intervals through the year 2030.

Options and costs for controlling emissions are represented by several emission reduction technologies. Critical load data and critical level data are often compiled exogenously and incorporated into the GAINS modelling framework.

The model can be operated in the 'scenario analysis' mode, i.e., following the pathways of the emissions from their sources to their impacts. In this case the model provides estimates of regional costs and environmental benefits of alternative emission control strategies. The Model can also operate in the 'optimization mode', which identifies cost-optimal allocations of emission reductions in order to achieve specified deposition levels, concentration targets, or GHG emissions ceilings. The current version of the model can be used for viewing activity levels and emission control strategies, as well as calculating emissions and control costs for those strategies.

The GAINS Model consists of several screen options, which display information pertaining to:

- Economic Activity Pathways: Activities causing emissions (energy production & consumption, passenger & freight transport, industrial and agricultural activities, solvent use, etc.)
- Emission Control Strategies: The evolution of emissions and control over a given time horizon
- Emissions Scenarios: Emissions are computed for a selected emissions scenario (combination of energy pathway and emissions control strategy), emission factors, results displays, and input values are also available under this action
- Emission Control Costs: Displays emission control costs computed for a selected emissions scenario
- Impacts: Presents ecosystem sensitivities and human health impacts of air pollution
- Data Management: Provides an interactive interface where owner-specific data can be modified, updated, exported, and downloaded

The project was completed 15 March 2008.

6.3 OBSERVATIONS AND REFLECTIONS

Only a modest part of the parties visited has experience with (or knowledge of) the EU-India cooperation in climate change and energy. It has therefore not been possible to make a comprehensive assessment. Nevertheless, the few statements have been organized under various headings below.

6.3.1 Added European value

Can EC add value to activities conducted by the EU Member States?

GoI official:

India has good and strong relations with UK and Germany (GTZ). It is difficult to see a justification for a separate EC initiative.

GoI official:

EU countries, and other countries, each have their competitive advantages:

- Germany (GTZ); largely in industrial energy consumption; provides expertise in specific technical issues (e.g. CHP); very much operational activities.
- France (Ademe); data and outreach.
- Switzerland; building design.
- Japan (MITI); largely in industrial energy consumption
- USA (USAID); largely energy consumption in buildings

EC has no comparative advantages; cannot deliver operational activities.

EC tells India the good things they should do, while India tells EC the good things they should do.

It is very difficult to cooperate with EC on activities yielding tangible results.

The Team's reflections:

- Cooperation with Member States has only been described in positive terms during this study. The Member States most active in air pollution and climate change are Germany (GTZ) and U.K. (DFID). Within climate change most has been done on CDM and adaptation.
- Joint Research Centres, the European Environment Agency and other European and multi-national institutions (such as IIASA) would be capable of adding value, e.g. in terms of regional modelling and regional inventories. The GAINS project is a shining example.
- Climate change appears to be an area, where EC can add extraordinary value, since EC is a key driver on the international scene.
- One means of getting most value for money is to conduct joint projects and programmes med EU Member States. GTZ in India already has several such projects with EC and is satisfied with the cooperation.

6.3.2 Scope of cooperation

EC official:

From the EU, there is too much focus on climate change as a driver for India. It took quite some time in Europe before climate change was one of the top political issues and that will be the case in India as well. Focus should rather be on other drivers which are accepted in India, but are important from a climate point of view such as energy efficiency, renewable energy, and energy security. These issues are top priorities for GoI, more than climate change.

EC official:

Climate change should be mainstreamed into development cooperation projects, research projects and other activities[35], and link more directly to the real drivers in policy development; e.g. economic growth, urban development, poverty eradication.

EC official:

A better cost-benefit understanding of climate change in India would be useful, in particular the costs of non-action; like a Stern report for India.

EC official:

GoI need a better understanding of the importance of the environmental industry as it is one of the fastest growing industries in the world and a real job creator, i.e. that it is in India's self-interest (from an economic development point-of-view and in terms of being less dependent of foreign technology and the IPR issues) to emphasize the economics of environment policy more.

6.3.3 Types of cooperation

GoI official:

India does not need financial assistance.

GoI official:

EC should assist where it really matters. Traditional capacity building will not add much value. Instead, real hands-on model pilot projects on the ground (learning-by-doing) are needed. Also, EC should facilitate real technology transfer.

EC official:

It is important to work and have agreements with institutions rather than with individual persons, who usually move on after a while, but without having committed their organisation.

[35] This actually complies with GoI's approach, which is to mainstream climate change in sustainable development ("India: Addressing Energy Security and Climate Change". Ministry of Environment & Forests and Ministry of Power (Bureau of Energy Efficiency), October 2007): "*Government initiatives for the diffusion of renewable energy and energy-efficient technologies, joint forest management, water resources management, agricultural extension services, web-enabled services for farmers and rural areas, and environmental education in schools and colleges represent a broad spectrum of efforts to integrate climate change concerns in sustainable development. This integration is institutionalized through specialized institutions, such as the Ministry of New & Renewable Energy, the Bureau of Energy Efficiency, and the Technology Information, Forecasting & Assessment Council, with specific mandates to promote climate friendly technologies*."

People tend to safeguard their professional spheres by not sharing knowledge. For the same reason, there is very little integration and coordination of policies between ministries in India.

Indian academic:

The sort of networking promoted by GAINS is good. It supported networking between Europeans and Indians, and in-between Indians; thus creating a working relationship, not only workshop gatherings. EC can continue supporting networking this way; otherwise networking is up to Indians.

Indian academic:

Full transfer of models will enable Indians to conduct state-of-the-art model development, thus contributing to the international community at equal footing. GAINS is such an example; it created mutual benefits.

Indian member of the Energy Panel:

The Energy Panel meetings have been useless. They are only addressing well-known issues and pleasantries. A radically new mechanism for technology transfer is needed.

6.3.4 Sustainability

European development officer:

Continuity may be at stake, if the cooperation primarily/only builds on (short-term) projects. Long-term in-situ cooperation and programmes are better for nourishing strong relations and commitments.

European development officer:

It is essential to maintain long-term working relations on the ground, to ensure demand-driven approach. As a good example, GTZ has several programme offices in India; e.g. a climate change office in MoEF and a pollution office in CPCB, and a pollution office in a state pollution control board.

European academic:

Continuity is also instrumental, when filling EC staff positions. The dynamic job-rotational practice of EC may hamper the development of the trust and confidence required for international cooperation. It may be considered to introduce longer terms for key international-relations staff and/or substantial time-overlaps (3-6 months), when positions are renewed.

The Environment Counsellor at the EC Delegation in Delhi is a new position. The current assignment is 4.5 years, until September 2012. Much value would be added to institutional remembrance and continuity of operations, if this position were supported by (permanent) local staff. This option is actually being discussed.

6.3.5 Implementation

<u>Choose the right partners</u>

EC officer:

As is the case in many countries around the world, MoEF is a very weak ministry. It has a low profile in government, and has had no Cabinet minister for a long period (in theory, the Prime Minister is also Environment Minister). Therefore, it is vital to also have good contacts with other relevant Ministries, such as the Ministry of Power, Ministry of Petroleum and Natural Gas, the Planning Commission as more and earlier results may come from also working with those other ministries. As an example, in the field of chemicals management the EC Delegation has started to also work with the Ministry of Chemical & Fertilizers and not only with the MoEF.

Speed and flexibility

GoI officer:

> For many government institutions, finance is not a barrier for implementing new initiatives. It is rather internal bureaucracy, which is the problem. Therefore, for a body such as CPCB, it is very convenient to have a GTZ programme office in-house, as they can act promptly.

GoI officer:

> The Bureau of Energy Efficiency (BEE) has one EC-funded project in the pipeline, about harmonisation of technical standards. It has been under way for more than a year, still not on the ground. This is not satisfactory.

6.4 CONCLUSIONS AND RECOMMENDATIONS

EC sponsored activities in climate change should be mainstreamed into development projects and programmes. The main thrust should be implemented as long-term working relations on the ground, targeting tangible results (i.e. more than studies and traditional capacity building). An efficient means may be to partner with those EU Member States, which have profound, long-lasting and pertinent programme activities in India.

ANNEX 1

GAPS AND CONSTRAINTS HIGHLIGHTED BY INDIA'S INITIAL NATIONAL COMMUNICATION

1. GAPS AND CONSTRAINTS HIGHLIGHTED BY INDIA'S INITIAL NATIONAL COMMUNICATION

India (Ministry of Environment & Forests) submitted its Initial National Communication (NatCom 1) to the UNFCCC on 22 June 2004 (www.natcomindia.org).

The Executive Summary has a paragraph and table (page XIV-XVI) on gaps and constraints for sustained communication activities.

Otherwise, it is chapter 7, which in more detail describes the constraints and gaps, and related financial, technical and capacity needs:

- The inventory estimation has to be made at a more disaggregated level, preferably at a Tier II or III levels (as per the Revised 1996 IPCC Guidelines for Greenhouse Gas Inventories) for most of the sectors, resolving the differences between top-down and bottom-up estimates.
- Finer sub-sectoral level estimates for activity data and EF have to be developed. Similar and consistent formats have to be adopted for data reporting and consistency by organizations generating activity data.
- Similar and consistent formats have to be adopted for data reporting and consistency by organizations generating activity data.
- Non-availability of relevant data, e.g. long time series for landfills, informal and less organized sectors of the economy, sub-categories of agriculture, and LULUCF.
- Data non-accessibility, e.g. data required is proprietary and considered confidential.
- Data organization constraints, e.g. data not organized in desired formats (requires considerable data organization), inconsistency in some data sets, sectoral data for various fuels do not match across different ministry reports in a few instances, sectoral definitions for different fuels may not be consistent.
- Development of representative (national) emission coefficients
- GHG inventory estimation on a continuous basis. The GHG inventory estimation needs may be estimated at three levels: Data needs; capacity development and enhancement needs; and institutional networking and coordination needs.

Table 7.1 (page 209) presents an overview of constraints and gaps.

Gaps and constraints	Description	Potential measures (examples)
Data organization	Published data not available in IPCC-friendly formats for inventory reporting	Design consistent reporting formats
	Inconsistency in top-down and bottom-up data sets for same activities	Data collection consistency required
	Mismatch in sectoral details across different published documents	Design consistent reporting formats
Non-availability of relevant data	Time series data for some specific inventory sub-categories, e.g., municipal solid waste sites	Generate relevant data sets
	Data for informal sectors of economy	Conduct data surveys
	Data for refining inventory to higher tier levels	Data depths to be improved
Non- accessibility of data	Proprietary data for inventory reporting at Tier III level	Involve industry and monitoring institutions
	Data not in electronic formats	Identify critical datasets and digitize
	Lack of institutional arrangements for data sharing	Establish protocols
	Time delays in data access	Awareness generation
Technical and	Training the activity data	Arrange extensive training programmes

Gaps and constraints	Description	Potential measures (examples)
institutional capacity needs	generating institutions in GHG inventory methodologies and data formats	
	Institutionalize linkages of inventory estimation with broader perspectives of climate change research	Wider dissemination activities
Non-representative emission coefficients	Inadequate sample size for representative emission coefficient measurements in many sub-sectors	Conduct more measurements
Limited resources to sustain national communication efforts	Sustain and enhance research networks established under Initial National Communication	Global Environment Facility (GEF)/ international funding
	India-specific emission coefficients	Conduct adequate sample measurements for key source categories
	Vulnerability assessment and adaptation	Sectoral and sub-regional impact scenario generation, layered data generation and organization, modelling efforts, case studies for most vulnerable regions
	Data centre and website	National centre to be established

Page 216: India would like to immediately launch the activities for preparing the Second National Communication, reflecting its commitment to the UNFCCC. India seeks further funding from the GEF for this purpose. Some of the proposed projects are indicated in Table 7.5. These include projects on improving inventory estimation, vulnerability assessment and adaptation research, and capacity building.

Table 7.5 (pages 217-221) contains 47 project proposals for improvements of future National Communications. The below table shows those proposals pertaining to monitoring of GHG from large industrial and power generation sources:

No	Type / Sector	Title	Description
Activity data for GHG inventory			
1	All sectors	Data format preparation for GHG inventory reporting	Presently the data being reported by the various ministries and departments at resources and sectors level shows some mismatch and the consistency cannot be easily verified. It is imperative that the available data formats be reorganized for reporting data at intra and inter ministerial levels in appropriate GHG inventory reporting formats.
3	Energy	GHG emission measurements and activity data assessment for biomass used for energy purpose	GHG emission measurements and activity data assessment for biomass used for energy purpose
4	Energy and Industrial processes	GHG inventory estimation	Data collection and GHG inventory estimation to climb the tier ladder to 2/3 tiers from the current Tier 1 for the various sub-sectors
9	Waste	Activity data improvement for	Data collection and GHG inventory estimation to climb

No	Type / Sector	Title	Description
		the waste sector.	the tier ladder to 2/3 tiers from the current Tier 1 for the various sub-sectors
Uncertainty reduction in inventory estimation			
10	Energy	Development of CO2 emission factors, linking coal beds with power plants, and impacts on their immediate environment, dispersion and transportation of emitted pollutants	(a) Power sector is one of the major contributors to the Indian CO2 emissions. This project envisages GHG emission measurements from 40 power plants (coal and gas based). (b) Evaluation of the changing sectors of coal use, including small-scale sectors. Investigation of characteristics of coal in the country, linking them to the various coalfields. Comparative evaluation of the reliability of emission measurements by direct measurement, traditional mass balance approach and the Continuous Monitoring System. (c) Carry out dispersal modelling and ascertain the levels of emissions in and around the plants. Explore the sequestration potential of planned forest cover around the plants.
12	Energy and industrial process	GHG emission measurement from large point sources—steel plants and cement plants	Due to high requirement of coking coal for steel production, the steel sector has a very high emissions per unit of production and contributes substantially to Indian CO2 emissions. Similarly cement production contributes significantly to energy and process based CO2 emissions. This project envisages GHG emission measurements from 10 steel plants and 30 cement plants. The process-based emissions will be distinguished and will be measured separately.
13	Energy	GHG emission measurement from large point sources—Petroleum Refineries	GHG emission measurements from five petroleum refineries.
14	Energy	Methane emission measurements from the coal mines	Cover a 100 coal mines, including opencast mining for methane emission coefficient measurements.
15	Energy	Methane emission measurement from oil and natural gas venting, flaring and transport	Cover all the major oil exploration sites in India
16	Energy	GHG emission measurement from informal/partially informal energy intensive Sectors	GHG emission measurements from fully/partially informal energy-intensive sectors like brick manufacturing, sugar and ceramics etc. About 10 sectors are proposed to be covered here. The major ones being brick (sample about a 100 kilns), sugar (sample about 50 units), soda ash (sample about five units), textile (sample about 20 units), ceramics (sample about 30 units), and chemical and dyes (sample about 30 units).
17	Industrial Processes	Reduction of uncertainties in GHG emissions factor in lime and cement sectors in India	This project will help to reduce the uncertainties in CO2 emission coefficients derived for the first phase of NATCOM. The work programme will entail systematic collection of CO2 fluxes, samples of raw materials, intermediate and final products for analysis. About 50 cement plants representing prevalent technologies for producing cement in India will be covered.
18	Industrial Processes	GHG emission coefficient measurements from industrial processes	GHG emission coefficient measurements from industrial processes like nitric acid production, aluminium production, soda ash use and pulp and

No	Type / Sector	Title	Description
			paper production.
Capacity building/ enhancement			
43	Inventory Estimation	To establish a GHG reference laboratory for generating and disseminating certified reference materials	(a) This will involve the preparation and dissemination of gas- CRMs of CO2, CH4, and N2O. Calibration of Gas Chromatographs (GCs) used for baseline monitoring for above gases. (b) Preparation of uncertainty budget for baseline monitoring for above gases for homogenization of uncertainty of measurements. Validation of test methods and organization of proficiency tests for measurement of the above gases.
44	Inventory Estimation	Nodal centre for synthesis and coordination of uncertainty reduction in GHG emissions	This centre will essentially validate, synthesize and ensure the application of good practices for uncertainty management and quality assurance and quality control. Periodic training will be conducted to update researchers on the latest good practice guidance techniques for undertaking measurements and also train personnel for undertaking measurements in various sectors. Following the guidance specified by the IPCC Good practices report, this agency will act as a third party for implementing the QA measures.
46	Energy	Setting up of an Indian energy systems model for medium and long-term energy and environmental policy	Economy-energy-environment modelling using Indian emission scenarios and shared databases developed under other projects. Major outputs will include the projection of alternate GHG emission pathways, energy intensities, technology and fuel mix, and energy sector investment requirements for India in medium to long term.
47	All sectors	Organizational and institutional issues for climate change	Creating awareness at all levels (grassroot to policy) on climate change, vulnerability and adaptation issues for industry and infrastructure, energy, agriculture, LULUCF sectors, through sectoral workshops in various (vulnerable) regions of the country; dissemination; publication, etc.
48	All sectors	Educating and informing the corporate sector about the emission abatement technologies and projects.	(a) Create awareness about climate change in the business sector, especially on impacts on industry, cleaner production, CDM, etc. b) Role of insurance as a tool of adaptation for long-life assets.

Some thematic potential project concepts that are over and above the specific projects presented above are presented in table 7.6 (pages 222-227). The below table shows those proposals pertaining to monitoring of GHG from large industrial and power generation sources:

No	Type / Sector	Title	Description
Abatement/ Capacity development			
30	Energy	To study the level of non-coking coal beneficiation and its impact on efficiency improvement/abatement of GHG emission in thermal power stations.	This will involve a detailed study of non-coking coals for identification of quality parameters including combustion behaviour. Estimation of the impact of coal quality on the boiler efficiency. Quantitative assessment of the effects of the variations of fuel quality on the performance of the critical sub-processes involved in power generation and GHG emission.

No	Type / Sector	Title	Description
31	Energy	Validation of the Multi Stage Hydrogenation (MSH) technology for converting coal to oil	(a) The aim is to confirm the results of the batch reactor studies. (b) Establish viability of the process through generation of technical data required upscaling the process to higher scale. (c) Research for increasing the present yield of distillates from 60% higher yields between 85% - 90 %; commercial viability of this project.
32	Energy	Utilization of GHG (CO2 and Methane) for production of fuels and chemicals.	This will involve conversion of CH4 and CO2, producing syngas with low H2 / CO ratio, (nearer to one) which is highly desirable in gas to liquid fuels conversion technology using iron-based catalysts. Conversion of methane gas by development of solid acid catalysts based on heteropoly acids and other catalysts to value added chemicals like methanol, formaldehyde and ethylene.
33	Energy	Abatement of GHG via *in situ* infusion of fly ash with CO2 in thermal power plant: upscaling of the process vis-a- vis associated carbon sequestration and adoption.	(a) This will involve characterization of fly ash samples from 2-3 representative thermal power plants of the country in respect of various physico-chemical parameters including minerals and trace and heavy metals content. Carry out experiments, under laboratory conditions, on CO2 infusion of these fly ashes at varying pressure. (b) Assessment of extent of infusion of fly ash and consumption of CO2 therein. Experiments on leaching characteristics of fly ashes (treated and untreated) with CO2 infusion following shake and column tests.
36	Energy	CO2 Sequestration in geologic formations with enhanced coal bed Methane Recovery.	This will involve examination of the potential for CO2 sequestration in geologic formations/un-mineable coal seams. Identification of un-mineable coal seams/ geologic formations in India suitable for CO2 sequestration. Develop mathematical models for reservoir simulation of CO2-CBM and a mathematical model for gaswater flow in coal beds.
39	Energy/petroleum	Energy/petroleum geological storage of CO2 in exploration/recovery of petroleum gas.	This will involve injection of CO2 in the petrioleum wells for recovery of petroleum gas and other products.
40	Energy	Energy Removal/absorption of CO2 through absorptive media	This will involve the identification, characterization of different absorptive media for CO2 removal and its absorption in thermal power plants.
41	Energy	Energy CO2 decomposition through plasma technology	This will involve the use of an arc discharge device where CO2 will be dissociated with ionized to give rise to carbon and oxygen ions. A directionally aligned magnetic field can be used to separate the carbon and oxygen ions. The carbon ions so deflected with the help of magnetic field can be separately collected.
43	Industrial Processes	Ecologically-friendly and value added steel making process based on VRDR-SAF-ESR route	The proposed process attempts use hot charging of DRI into submerged arc furnace (SAF)/ Electro-slag Crucible Melting Furnace (ESCF), from which the hot liquid steel enters the electro-slag casting equipment to produce high quality alloyed steel product of near-net shapes. The process is expected to be environment friendly and techno-economically attractive even on a medium scale of operation. The process has the flexibility to treat various feed materials and produce a range of different steel

No	Type / Sector	Title	Description
			products based on the local demand. Since the DRI-based route by-passes the conventional components such as coke and sinter making, the process would require much less energy and would lead to substantial reduction in emission of CO2 to the atmosphere.
44	Industrial Processes	Non CO2 GHG emission abatement from process industries.	Abatement demonstration projects in industries such as nitric acid, paper, adipic acid.
51	Energy, Industry and Infrastructure, and Waste	Issues in technology transfer for abatement of GHG emissions in India	Facilitating transfer of technology from developed to developing countries. Through joint research and development, and adoption.
52	Industry	Fiscal instruments for emission abatement from Indian industry	Research and pilot projects.
53	Energy	Role of technology in abatement and adaptation of climate change impacts on energy sector	Conduct intensive studies for abatement and adaptation of energy efficient technology and methods and identify points of leverage in market chains and institutional regimes for demand side management measures for abatement.
64	Waste/Energy	Waste to energy	Efficient utilization of organic solid wastes for energy and resource recovery and GHG abatement.
66	Energy	T&D losses	Reduction in transmission and distribution losses
67	Energy	Waste to energy	Power generation from refinery residues using IGCC technology.
68	Energy	Carbon abatement	Reduction of carbon emission by renovation and modernisation of old coal-fired thermal power plants.
69	Energy	Carbon abatement	Efficiency improvements in the Indian brick industry.
70	Energy	Carbon abatement	Demonstration of coal gasification and supply of coal gas to tunnel kilns in pottery.
71	Energy	Waste to energy	492 MW IGCC power plant, based on refinery residue-vistar
72	Energy	CO2 capture and storage	Identification and carrying out geological mapping of potential areas for CO2 capture from large point sources and subsequent storage in India like in sedimentary rocks, un-mineable coal seams, depleted oil wells, etc to evaluate total CO2 storage capacity available in the country and its long term implications.
73	Energy	Fuel Switching	Design and development of zero emissions coal fired thermal power stations wherein coal will be gasified and CO will be converted in CO2 by shift reaction and hydrogen will be used for power generation employing fuel cell / turbine to get zero emission power.