Clean Development Mechanism Project Opportunities in India

TERI, New Delhi

January 2001

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Introduction

Over the last three years, the CDM (clean development mechanism) has generated a lot of hype, hope, and scepticism. The ratification of the Kyoto Protocol hinges mainly on the resolution of issues related to the operationalisation of the CDM. In the meantime, efforts have been made to identify possible opportunities for the implementation of CDM projects in developing countries.

The present report analyses India's developmental priorities to present a set of projects that would likely be accepted by the GoI (Government of India). The report first gives the background to the government's policy on climate change with reference to the CDM and describes the CDM-related activities of various stakeholders in the economy. The next section focuses on emissions from the Indian economy to put the possible mitigation options in context. The penultimate section reviews the existing literature and the government's developmental priorities to identify priority CDM projects. The last section of the report analyses the identified CDM options for India.

Climate change policy and government stand on CDM

Climate change policy: structure and principles

The GoI is a signatory to the UNFCCC (United Nations Convention on Climate Change) and ratified the Convention in November 1993. The MoEF (Ministry of Environment and Forests), which is the nodal ministry for all environment related activities in the country, is the nodal ministry for coordinating the climate change policy as well. The Working Group on the FCCC was constituted to oversee the implementation of obligations under the FCCC and to act as a consultative mechanism in the government for inputs to policy formulation on climate change. To enlarge the feedback mechanism, the GoI has constituted the Advisory Group on Climate Change under the chairmanship of the Minister of Environment and Forests. Invitees to the advisory group include representatives of line ministries, research institutes, and civil society.

The policy of the GoI on climate change is based on three broad principles.

1. The primary responsibility of reducing GHG (greenhouse gas) emissions is that of developed countries. They should show a demonstrable sincerity in initiating actions to address climate change.

2. The development needs of developing countries are of prime importance.

3. The developed world should transfer resources and technologies at favourable terms to the developing world, thereby facilitating developing countries to move towards a sustainable development path.

CDM: the government perspective

The CDM represents a step forward from AIJ (activities implemented jointly) to a crediting regime. AIJ was proposed, under considerable reservations by developing countries, as a pilot phase to operationalize Article 4(2) of the FCCC. After great deliberation on participation in AIJ, the GoI set up the AIJ Working Group in the MoEF, and issued a set of guidelines for submission of AIJ projects to the government. Under a set process to evaluate and approve AIJ projects, a number of projects have been approved with the aim of gaining experience in implementing AIJ-type activities.

The CDM too was viewed with reservations, especially since the Kyoto Protocol text did not clearly state the guidelines for the mechanism. It has been debated on at length taken place since 1997 and broad consensus seems to be emerging on some issues regarding the operationalization of CDM. This is reflected in a much thinner consolidated text that emerged after SBSTA-12 (12th session of the Subsidiary Body on Scientific and Technological Advice).

The GoI has since set up the Expert Group on Kyoto Protocol Mechanisms to crystallize the views in the country, on which TERI too is represented. There has been a shift in the Indian stand towards accepting the CDM conditional to the clarification of principles and modalities of operating the mechanism. This shift is underlined by the joint statement between India and United States on 'Cooperation on energy and environment' signed in March 2000. Stressing on the desire to promote clean energy, it called for development of cleaner and more efficient energy technologies. The statement said that by 2012 GoI hoped to increase the share of renewable energy to 10% of the capacity addition in electricity generation.

The following are key elements of the Indian stand on the CDM.

1 The use of flexible mechanisms to meet commitments should be supplemental to domestic effort and an upper limit to their use should be defined.
2 Sinks should not be included in the CDM.
3 Criteria for CDM projects
   a Host country to be sole judge of the national sustainable development criteria.
   b The project activity shall promote transfer of technology.
   c Capacity building should be incorporated in all CDM projects.
   d Baselines will be defined on a project-to-project basis.
   e Funding for project activity shall be additional to ODA (official development assistance), GEF (global environment facility), and other financial commitments of developed country Parties.

4 The 'share of proceeds from certified project activities' shall be a stipulated percentage of the differentials of the costs incurred by the developed country Party in reducing GHG through a project activity in a developing country and of the project costs that would have been incurred had the GHG reduction activity taken place in the developed country funding the project.

5 The terms and conditions for sharing CERs (certified emissions reductions) and funding will be mutually agreed upon by the developed and developing country Parties.

6 The operational entities to certify emission reductions shall be designated by the COP/MOP (conference of parties to the Convention serving as the meeting of parties to the Protocol).

7 A national system of monitoring, verifying and reporting under the CDM shall be established.

Recent CDM-related initiatives

Several efforts have been made by both research organizations and industry federations to create awareness and to disseminate information regarding CDM among various sections of society.

TERI

TERI, a not-for-profit research institute, has been working in the area of energy and environment for the last 25 years. It has a dedicated centre on climate change called the Centre for Global Environment Research. TERI's Repository of Environmental Activities and Technologies, or TREAT (www.teriin.org/treat/treat.htm), was one of the earliest initiatives launched in India to sensitize the corporate sector to business opportunities under AIJ and CDM. The core activities are capacity building and training through regular interaction and the organization of national workshops, symposiums, and conferences. Recently, TERI has developed project proposals for private entrepreneurs for the CDM.

Development Alternatives

DA (Development Alternatives) is an NGO that has been active in creating capacity to develop projects. The thrust of many DA projects is social objectivity and utilization of the traditional knowledge base. Thus their focus is on facilitation of renewable energy and applicability of projects in rural environmental settings in India.

Confederation of Indian Industry

CII (Confederation of Indian Industry) has started a Climate Change Centre (www.ciionline.org/climatechange) with the following objectives

- Spread awareness on climate change issues within Indian industry.
- Promote consensus on climate change mechanisms, particularly the CDM, within Indian industry.
- Build local capacity to develop climate change mitigation projects.
- Develop position papers on climate change policy issues.
- Facilitate dialogue between Indian and US business executives to set the tone for collaborations on climate change mitigation projects.
- Conduct seminars and training workshops.

Federation of Indian Chamber of Commerce and Industries

FICCI (Federation of Indian Chamber of Commerce and Industries), another large industry confederation, is also actively promoting the CDM. FICCI, in collaboration with ICICI has initiated the EIC, or Environmental Information Centre. The main objectives of the EIC are (1) to promote and facilitate industry actions for environmental improvement and management, and (2) to compile and disseminate information relevant for business on global climate change, energy efficiency, clean and climate friendly technologies, and other environmental issues. It has developed a Climate Change India web site jointly with Hagler Bailly Services Inc. (www.climatechangeindia.com/climatechange).

India, with a good human resource base, a vibrant service sector, and increasing awareness provides a good base for developing and implementing CDM projects.

Current emissions and projections

The latest and most comprehensive national GHG inventory for India was prepared under the GoI-endorsed ALGAS[a] project (ADB 1999), a summary of which is presented below.

- On a CO_2 equivalent basis, CO_2 emissions account for 53% of the total emissions. CH_4 and N_2O contribute 39% and 8% respectively.
- The energy sector is the main emitter of CO_2, accounting for 87% of the total emissions, the rest coming from the cement industry (4%) and land conversion (9%).
- Biomass burning and agriculture sector are the main sources of CH_4 and N_2O emissions. A small portion is contributed by the transport sector.

Table 1 summarizes sectoral emissions of CO_2 from energy consumption. These estimates are based on the fuel consumption within each sector.

- Fuel combustion in the industrial sector, power generation, and transport sector account for 41%, 34%, and 17% of the total emissions respectively.
- The main source of energy in India is coal. Coal is mainly consumed for power generation and industrial energy requirements, and accounts for 62% of the emissions.
- Total emissions from the energy sector grew at 5.8% between 1989/90 and 1994/95.
- The largest growth in emissions for the above period was in the power generation sector, which grew at 8.6%. Industrial sector emissions grew at 4.7% annually.

Table 1 Sectoral Emissions (Gg)

Sector	1989/90	1994/95	CAGR[a] (%)
Power Generation	175126	262932.60	8.47
Industry	207878	261483.00	4.70
Transport	86226	103659	3.75
Residential	30256	35713	3.37
Commercial	6646	6912	0.79

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[a] ALGAS: Asia Least Cost Greenhousegas Abatement Strategy

Sector	1989/90	1994/95	CAGR[a](%)
Agriculture	1797	2756	8.92
Total	507,932	673,457	5.80

[a]*compounded annual growth rate*

Source: ADB-GEF-UNDP (1998)

Projections of the ALGAS study indicate that total emissions will grow from 532 Tg in 1990 to 1555 Tg in 2010 and 2308 Tg in 2020 (ADB 1999). Emissions from the energy sector will increase fivefold by 2020. These estimates incorporate the effects of future technological improvements on total demand. They indicate that opening of markets for import of petroleum and gas will lead to some substitution, but given the abundance of coal in the country, it will continue to be the dominant source of energy. One of the major sources of emissions in future will be power generation. The Fifteenth EPS (Electric Power Survey) estimates the all-India peak demand to reach 176 GW by 2012, and the total energy requirement of 1058 billion units (TERI 2000). Coal-fired power generation will form a major share of capacity additions.

The industrial sector consumes about 50% (including feedstock) of the total commercial energy produced in the country. The total industrial energy consumption, including non-energy uses, grew from 45.7 MTOE (million tonne of oil equivalent) in 1984-85 to 113.1 MTOE in 1996-97. The most energy-intensive industries are fertilizer, iron and steel, aluminium, cement, and paper and pulp. These industries account for nearly 65% of the total industrial energy consumption. Table 2 shows the estimates of energy consumption for these industries, which have been calculated on the basis of energy consumption norms and existing production capacities. The current energy consumption norms are greater than international norms, and there is much scope for upgrading technologies in these sectors.

Table 2 Estimated energy consumption in major industrial sectors:1991

Sector	Energy consumed (G Kcal)
Iron and Steel sector	147035
Fertilizer	149533
Cement	68899
Aluminum	32588
Pulp and Paper	20600
Total energy consumed in the above sectors	418655
Total energy consumed in the industrial sector	641580*

Source : TERI (2000). Note: The figures are for 1990-91

Climate Change Mitigation Options and Activities

Sector options

The inventory presented above shows that the major increase in emissions over the next 20 years would be related to energy consumption in the economy. Energy efficiency and increasing use of renewable energy (or a move towards low carbon options) are the two main measures that can greatly reduce emissions. Power generation, specifically coal-based power generation, has great potential for mitigation. Transmission and distribution losses are the other major source of energy losses and, hence, emissions. There is considerable scope of reducing losses, which translates into a large mitigation potential. Mitigation options in the power sector include clean coal technologies and renewables. Options such as bagasse-based cogeneration and combined cycle plants are already profitable and generate fewer emissions per kilowatt-hour of electricity than conventional generation.

Alternative low carbon fuel options to current energy sources are another major mitigation option. Short-run options include fuel-switching to lower carbon fuels, which to some extent will be taken up by the economy on its own. In the medium and long run, the use of renewable energy, both centralized and decentralized, is an important mitigation option. Small hydro-, wind- and biomass-based power, although more expensive than conventional coal-based plants, provide significant abatement opportunities. Renewable options for irrigation provide a reliable energy option. With a vast rural population and several remote areas, renewable energy could be the means to clean energy and prosperity in India.

Energy consumption in industrial processes is another area where substantial reductions can be achieved. These include both efficient process and other demand-side management options. Typically, these options lead to an improvement in energy efficiency and resource conservation and introduce advanced technologies, thus laying the foundation for long-term sustainable development. Opportunities in the iron and steel and cement industries are significant.

ALGAS presents a comprehensive list of options in energy efficiency and renewable energy, which are listed in Tables 3 and 4. These options were selected on the basis of three main criteria.

1. Consistency with national development priorities.
2. Relatively high level of energy consumption in the base activity.

3. Relatively large GHG reduction potential offered by the abatement technology.

Table 3 Supply-side and demand-side energy sector options

Power sector	Industrial sector	Domestic sector
Combined cycle plants Integrated Gasification Combined Cycle (IGCC) Inter-cooled steam injected gas turbine (ISTIG) Pressurized fluidized bed combustion (PFBC) Pulverized coal super-critical boilers Industrial cogeneration Amorphous core transformers	Diesel Cogeneration **Iron & Steel** Basic oxygen furnace Ultra-high-power electric arc furnace Continuous casting Direct reduction process Dry quenching route **Paper** Continuous digesters in paper industry **Cement** Dry kilns Dry preheater kilns **Caustic soda** Membrane process Soda Ash Dual process and Akzo lime process Waste heat recovery High efficiency burners (low excess air) Heat pump High efficiency motors Efficient lighting	Efficient refrigerators Efficient air Conditioners Efficient lighting (including the commercial sector)

Table 4 Renewable energy options

Power generation	Domestic sector	Agriculture sector
Biomass-fired power generation Solar (PV) photovoltaic power Solar thermal power Wind farms Small hydropower	Improved biomass cookstoves Biogas plants Solar cookers PV home systems PV lanterns	PV water pumps Wind pumps Biomass gasifiers

CII has also assessed the potential of mitigation in various sectors based on different reports (www.ciionline.org/climatechange). These are presented in Table 5.

Table 5 Mitigation potential of different interventions

Project category	Emissions mitigation opportunity	Size of opportunity (electric generation)	Overall investment potential (billion dollars)	Energy benefits expected	Carbon reductions expected)
Coal washing	Reduce ash content from 40% to 30%	5000 - 6000 MW of capacity	1.8	5500 Btu/kilo coal	11 million tonnes annually
Fuel switch	Imported LNG in current coastal coal plants	38000 MW	3.1	0.15 kg carbon per kWh	4 million tonnes annually
Conventional efficiency	Improve thermal efficiency by 1.5%	6500 MW	0.15	Not available	4 million tonnes
Integrated gasification combined cycle	Install IGCC technologies	10000 MW	10	2000 Btu/kWh	5 million tonnes annually
Renewables	Wind, solar, bagasse, and mini hydro	35000 MW	25	0.35 kg carbon per/kWh	60 million tonnes annually

Sources: CII (2000)

Review of AIJ and GEF projects

To assess the possible projects that would be approved by the GoI, we review the projects that have been approved and sanctioned by the government under AIJ and GEF. Table 7 shows the projects submitted under AIJ and considered by the GoI.

Table 7 AIJ projects sanctioned by the Government of India

Project title	Indian partner	Foreign funding
Direct reduced iron project	M/S Essar, Gujarat	Japan
Integrated agricultural DSM	Andhra Pradesh State Electricity Board	World Bank
Desi Power biomass gasification	DESI Power, Development Alternative	The Netherlands
Tamarind forest agroforestry in dry lands	ADAT, Bagepalli, Karnataka, India	United States
Energy recovery from waste gas and liquid	IPCL	Japan
Hybrid renewable energy systems		Australia
Methane emission reduction from enteric fermentation by using multi-nutrient urea blocks		Canada

Of the above projects the direct reduced iron project could not be concluded due differences over transfer of technology. The methane emission reduction project was not approved because the technology proposed under the project was considered to be available within India.

The GEF portfolio in India is diverse and varied. As of January 1998, 142.48 million dollars has been programmed for India under GEF, of which 119.74 million dollars is allocated to climate change projects. Table 8 lists projects in the climate change area, and indicates that the concentration of projects is mostly in energy options, specifically renewable energy options.

Table 8: GEF[1] climate change portfolio in India

Projects	GEF allocation (million dollars)		
Implementing agencies	UNDP	World Bank	IFC
Operational projects			
Optimising development of small hydel resources in hilly regions of India	7.5		
Development of high rate biomethanation process as means of reducing GHG emissions	5.5		
ALGAS[2]	0.85		
Alternate energy development project		26	
Selected options for stabilizing GHG emissions	1.5		
Coal bed methane capture and utilization	9.9		
PDF B[3]			
Carbon emission reduction through biomass energy	0.196		
Fuel_cell buses			
Pipeline projects			
India energy efficiency project		5	
Solar thermal electric project		49	
Photovoltaic market transformation initiative (PVMTI) – Regional project			15

Source: Ministry of Environment and Forests, Government of India

[1]Global Environment Facility; [2]Asia Least-cost Greenhouse Gas Abatement Strategy; [3]Project Development Facility

The majority of support through GEF is concentrated on strengthening the infrastructure to promote renewable energy in India and increase its share. The Alternate energy development project aims at commercialization of solar PV (photovoltaic) and wind technology in India. The biomass, small hydro, fuel cell, and biomethanation projects are aimed at demonstrating the technology to promote its use.

CDM project opportunities

Investors will prefer CDM projects that satisfy three basic criteria.

1. High possibility of approval by the government.
2. Low transactions costs.
3. Significant reduction potential.

Energy sector priorities

Despite a slow start, the GoI is now actively trying to access GEF funds. This is partly because some of the activities have a high overlap with the developmental objectives of the government. The GoI has identified the following project ideas in accordance with its development objectives.

- Removal of implementation barriers of biomass-based power generation.
- Strategy for removing barriers in achieving industrial energy efficiency.
- Carbon reduction through grid-interactive PV power generation.
- Energy conservation through technological upgradation of steel rerolling mills.
- Solar PV diesel hybrid systems for decentralized village electrification.
- Cogeneration in cement plants.
- Carbon emission reduction in power plants.
- Decentralized rural electrification through biomass and solar energy through private participation.
- Switching to non-petroleum fuels, electricity-powered and hybrid engines in transport sector.
- Demand-side management in basic material and construction industry.
- Improving efficiency of rural agriculture pumpsets.
- Energy conservation in paper industry.

As the above list shows, the priority options for the GoI are efficient technologies in power generation, centralized and decentralized renewable energy options, and energy efficiency in steel and paper industries. The text submitted by India on flexible mechanisms states that no forestry sector projects will be allowed. Preference will be given to projects in the renewable sector and those with a focus on energy efficiency improvements. Projects that improve the quality of life of the very poor from the environmental standpoint and promote state-of-the art, environmentally sound technology will be sought.

The energy sector mitigation options identified above were ranked by policy makers on the basis of

- cost of mitigation
- feasibility of the option
- environmental and other benefits
- consonance with the overall development priorities of the country.

Table 9 presents the overall ranking of options that was done through an analytical hierarchical process or AHP (ADB 1998; Pathak, Srivastava, and Sharma 1999).

Table 9 AHP (analytical hierarchical process) results for India

	AHP
Conventional power generation	
Bagasse-based cogeneration	1
Combined cycle generation (natural gas)	2
Integrated gasification combined cycle	3
Pressurized fluidized bed combustion	4
Atmospheric fluidized bed combustion	5
Pulverized coal super-critical boilers	6
Renewables for power generation	
Biomass power	1
Small hydro	2
Wind farm	3
Photovoltaic	4
Renewables for agriculture	
Wood-waste-based gasifiers	1
Agro-waste-based gasifiers	2
Photovoltaic pump	3
Wind deep well	4
Wind shallow well	5
Cement	
Dry suspension preheater kilns	1
Dry precalciner kilns	2
Transport	
Mass rapid transport system	1
Compressed natural gas car and bus	2

Priority CDM projects

Based on the above information, the following projects are proposed for CDM in India.

Power generation

1 Coal power plant using IGCC (integrated gasification combined cycle)
2 Coal power plant using PFBC (pulverized fluidized bed combustion)
3 Renovation and modernization of power plants

Renewables

4 Wind-based power generation (grid connected)
5 Solar-thermal energy for power generation (grid connected)
6 Wind pumps for agriculture

Industrial efficiency

7 Direct reduction process in iron and steel industry
8 Continuous pulp digesters in pulp and paper industry
9 Demand-side management: efficient motors

Power generation

India currently has an installed power generation capacity of about 87481 MW, which is insufficient to meet the demands of the country. The demand for power has been growing at the rate of 9 per cent a year and is likely to accelerate because of the economic liberalization policies of the GoI. TERI estimates the power demand in India will be 385000 MW by the year 2020, requiring 380 billion dollars of investment in the power sector alone. Of the total generation capacity of the nation, 71% is based on coal. With proven reserves of about 70 billion tonnes and estimated reserves of about 200 billion tonnes, coal will continue to be the dominant fuel for power generation in the country. Hence introduction of cleaner technologies for coal utilization is one of the sustainable objectives of the nation. The proposed options for power generation are

1. Coal power plant using IGCC
2. Coal power plant using PFBC
3. Renovation and modernization of power plants

Coal power plant using PFBC

PFBC is a clean and efficient technology for coal-based power generation. In this technology, the conventional combustion chamber of the gas turbine is replaced by a pressurized fluidized bed combustor. The products of combustion pass through a hot gas cleanup system before entering the turbine, thereby reducing the amount of CO_2 emitted through combustion. The CO_2 reduction from a per unit of power supplied at bus bar using PFBC, over the conventional technology is 0.18 kg. Replacing a conventional plant of 500 MW capacity with a PFBC plant will result in CO_2 emission reduction of 0.58 million tonnes a year. The national mitigation potential for this technological option has been calculated at 8.166 million tonnes of CO_2 annually.

As PFBC technology has a high capital cost, the cost of production is marginally higher than that from a conventional power plant. But savings in coal compensate for the higher costs. The technology results in considerably lower emissions of SO_2 and NO. The technology therefore has a good potential both from a commercial and an environmental perspective.

Coal power plant using IGCC

IGCC is one of the technologies being explored to improve the efficiency of power generation and reduce the environmental burden. A coal gasification combined cycle technology centres around two elements:

1. A gasification plant that converts the fuel into a combustible gas and purifies the gas.
2. A combined cycle power plant which produces synthetic gas that fuels a gas turbine whose hot exhaust gases are used to generate steam to drive a steam turbine.

The efficiency of the IGCC is the product of the gasification system efficiency and the combined cycle efficiency. The auxiliary power consumption in oxygen blown gasifier is much higher than air blown gasifier and other pulverized coal plants. It is approximately 20% of the gross output. The air separation plant is very energy intensive because of the cryogenic process involved for the production of oxygen. However, the net efficiency of this technology is significantly higher because of the higher calorific value of the synthetic gas produced. For the second-generation technologies, net efficiencies are expected to be in the range of 45%-50%.

The current capacity of thermal power plants (existing and sanctioned) is 12647 MW, and the GoI has cleared another 16898.5 MW capacity for implementation. These plants are expected to have a net efficiency of 36% whereas the state-of-the-art IGCC plants have net efficiencies of 46%. Estimates based on above efficiency levels indicate that an IGCC plant will result in CO2 emission reductions of 0.25 kg/kWh. Replacing a conventional plant of 500 MW capacity with an IGCC plant will result in CO_2 emission reduction of 0.69 million tonnes. Assuming that IGCC would be adopted for 10% of the capacity sanctioned, 1690 MW, the total potential for emission reduction using IGCC will be 2.33 million tonnes of CO_2.

The proposed IGCC power plant will reduce emissions of SO_2, NOx, and SPM (suspended particulate matter). It will also reduce solid waste disposal by nearly 70% compared to direct coal-fired plants. An IGCC plant consumes is 0.46 kg of coal for one unit of power generated as opposed to conventional plant's consumption of 0.60 kg/kWh. This reduces energy use and resource spent on producing and transporting coal. The demonstration of this technology will reduce its implementation cost. The planned activities are expected to advance the financial, technological, and economic viability of the technology, creating distribution channels for manufacturing and engineering activities related to gasification technology, advanced gas turbines, and other IGCC/power-related activities.

Renovation and modernization of power plants

With increasing demand for power, the state-of the art power plants can possibly meet all the requirements but the constraint is the extremely high cost resulting from the high capital cost. Many old and inefficient power plants that contribute to the grid could be upgraded to work efficiently. For a developing country like India, where there is a shortage of financing for additions to capacity and a large number of inefficient and old plants still in operation, renovation and modernization can greatly help improve efficiency, as this just entails a replacement of parts of the plant. Most of the small plants running on coal in India operate below 30% efficiency. Increasing the efficiency could lead to huge amounts of reductions in the emission of CO_2 from this sector. But renovation and modernization has been very slow in the country mainly due to paucity of funds.

The proposed project looks into the renovation and modernization of existing old inefficient power plants in the country and will result in reductions in the emissions of SO_2, NO_x, and SPM. The project would reduce coal consumption which in turn would greatly reduce CO_2 emissions.

Renewables

Wind-based power generation (grid connected)

Wind is one of the important grid-connected renewable energy resources. The installed wind capacity as of December 1999 was 1080 MW. A huge potential remains unexploited and the GoI is addressing institutional and policy issues to increase the spread of wind based capacity. The MNES (Ministry of Non-conventional Energy Sources) to raise the share of renewable energy in total installed capacity of grid electricity generation to 10% by 2012.

India has a potential of 35 000 MW at 30 m hub height and 45 000 MW at 50 m hub height. The installed capacity is 1080 MW. Over the years the performances have increased with improving CF (capacity factors), with some projects achieving 30% CF. Concessional interest rates, favorable buy-back rates, and other fiscal policies support the wind energy projects. The availability of extra finances for the project can improve the feasibility and, hence, the rate of increase in capacity. The capacity addition in the first three years of the Ninth Plan (1997-2002) was 180 MW. Given the current requirement of 12 000 MW capacity a year to keep up with the demand, the GoI is aiming at 1200 MW from renewable sources. A more realistic capacity addition rate is been 4000 MW a year, and the target for renewable capacity additions would be 400 MW. Based on the past experience, and improving policy environment, a realistic estimate of capacity addition from wind would be 100-200 MW. The additional capacity in power generation is assumed to replace the planned thermal capacity in the country, which is expected to have design efficiencies of 38%.

Solar thermal energy for power generation (grid connected)

The utilization of solar thermal energy for power generation is likely to be higher on the list of priorities of the Ministry of Power and that of the MNES as it has a great potential for GHG reduction. It is a clean technology and does not involve use of any conventional fuel, fossil or otherwise.

The Fifteenth Electric Power Survey shows that the energy requirement at power station will be the highest for the northern region. The proposed option includes the installation of parabolic trough system to generate power using solar thermal energy. The specific option considered looks into the installation of solar thermal plants of capacity 500 MW. Given that use of solar thermal energy for power generation requires intensive solar radiation, northern region is suitable location since the Thar Desert of India falls in the region. Population is concentrated in and around urban areas of this desert region. Thus provision of space, a major requirement for setting up of solar plants, would be ideal in the region given the intense solar radiation available.

Wind pumps for agriculture

India has a large potential for wind energy. Apart from an estimated potential of 45 000 MW of wind-based power, the country can use wind energy directly to pump out water for irrigation and drinking purposes. If harnessed effectively, this option would reduce considerably the use of diesel and grid electricity in conventional pumps, thereby conserving fossil fuel and offsetting environmental concerns related to their use.

There are about 5 million diesel and 4 million electric pumps operating in the agricultural sector. The MNES has been installing geared-type deep well wind pumps under its demonstration programme and providing financial incentives for wider dissemination of the technology. A wind pump with rotor diameter over 5 m at a windy site can replace a 5 HP diesel or electric pump. Based on this observation, the incremental cost of CO_2 saved by switching from electric to wind pumps was estimated. Assuming the requirement of water to be 10 000 litres a day, 365 days a year, it was concluded that wind pumps could meet the water requirements during lean periods. Using a discount rate of 10%, and taking the average life of the pump as 20 years, an analysis showed that the option has tremendous carbon saving potential at relatively low cost. (Please refer to template in section B).

Industrial efficiency

Continuous digesters in pulp and paper industry

The pulp and paper sector is one of the oldest industries in India. Presently there are about 400 pulp and paper industries: 364 in the small-and mediumscale sector and 36 in the large-scale sector. The combined annual installed capacity of these mills is 6.2 million tonnes. The domestic demand for paper and paperboard is expected to increase from 3.05 million tonnes in 1998/99 to 3.6 million tonnes in 2001/2002 at a CAGR (compounded annual growth rate) of six per cent. With increasing demand in paper and paper products, large pulp and paper plants are expected to be installed during the next two five-year plans.

The proposed technological option is to adopt one of the energy efficient measures in the pulp and paper industry. The capacity of continuous digester process that can be installed was estimated at 1.29 million tonnes a year (TERI 1998). Though the actual penetration level of continuous digester technology is only 9% of the total installed capacity, there is a scope to increase this 30%. The adoption of this technology would increase energy efficiency and reduce CO_2 emissions. It was estimated that using continuous digester technology 690.96 kg of CO_2 could be avoided per tonne of paper and the total CO_2 avoided would be 675.75 kilo-tonnes a year.

The case considered for adoption of this option is a typical plant size of capacity of 300 tonne a day. The demonstration of this technology will reduce its implementation cost. The planned activities are expected to advance the financial, technological, and economic viability of the technology, creating distribution channels for manufacturing and engineering activities related to continuous digester technology and other activities in the pulp and paper industry. This project will provide a large quantum of CERs and the monitoring and measurement procedures are simple.

Direct reduction process in iron and steel industry

It is estimated that the demand for finished steel in India will cross 55 million tonnes a year by 2010. To meet these demands, the GoI has encouraged private Indian and foreign investments in the iron and steel industry to build new plants and modernize the existing ones. In response to policy changes, many steel producers are modernizing and expanding facilities and diversifying their product range. The Indian government’s emphasis is on expansion and modernization of the existing facilities by technological improvements. The major changes would include

- switching from OHF (open hearth furnace) to BOF (basic oxygen furnaces)
- greater use of LD (Linz Donowitz) convertors

- installation of continuous casting lines to maximize yields
- reduce energy consumption and use computers

The expansion and modernization programme considered in six of the public sector integrated steel mills (SAIL and VSP) is estimated to cost over 9 billion dollars.

The mitigation project that is considered in this option is related to coke making using the DQC (dry quenching of coke) process. The option suggested is the adoption of this technology in the base case, which is a SAIL plant, as part of the modernisation programme of the public sector iron and steel industries in the country. The potential for reduction by adopting the DQC process, in which 320-360 billion kcal/year heat can be recovered in the form of high pressure superheated steam, is at the rate 0.45 tone per tonne of coke cooled. The CO_2 emissions that can be avoided in the sector using this technology is to the tune of 950 kilotonnes a year and the incremental cost of abatement for a tonne of CO_2 is $10. In terms of direct benefits alone, such a project is estimated to have a payback of 3-4 years. The total CO_2 emissions that can be reduced by the adoption of this technology in the base case, which is a SAIL plant, is 155.977 kilotonnes of CO_2. The incremental cost is $15.58 for a tonne of CO_2 saved.

Efficient industrial motors

The industrial sector is the largest consumer of electricity in India. It consumes about 50% of the total commercial energy produced in the country. The major electricity-intensive industries are textile, chemicals, iron and steel, aluminum, fertilizer, cement, paper, non-ferrous, and collieries. In these industries, energy efficiencies are much lower than in industrialized countries. Studies show that the potential for energy conservation in the industrial sector is 20%-25% of overall energy consumption. In the context of rapidly increasing electricity demand and shortfalls in electricity availability and generating capacity, the need for efforts for conservation and improving efficiency becomes important.

It has been estimated that 60%-70% of the total electricity consumed by industries is consumed by electric motors. Electrical motors are used in industrial applications such as pumps, compressors, fans, and blowers, agitators crushers, pulverize, and conveyors. The type and sizes of motors used in industry vary widely, although AC squirrel cage induction motors constitute the bulk of the motors used. Since electric motors comprise a single relatively homogenous end-use category, small amount of savings on the percentage basis will result in significant potential for energy conservation within the industrial sector.

The proposed option lies in replacing existing old AC squirrel cage motors with energy efficient motors in the HT industry. This will lead to sizeable amounts of energy conservation and reduced CO_2 emissions.

Table 10 Abatement costs and national CO_2 carbon dioxide mitigation potential for some options.

Option	Incremental cost of abatement ($/tonne of CO_2	National mitigation potential (thousand tonnes of CO_2
Power generation		
Integrated gasification combined cycle	30	14610
Pressurized fludizied bed combustion	1	8166
Renovation and modernization	30	8579
Renewables		
Wind power (grid connected)	31	526
Solar thermal power (grid connected)	168	300
Wind pumps for agriculture	20	<1
Industrial efficiency		
Pulp and paper – continuous digester	11	904
Iron and steel – dry quenching	10	950
Replacement of industrial motors	14	36

Analysis

Project opportunity: Replacement of conventional coal technology with IGCC

	Baseline	Project opportunity
Description	Conventional coal technology	IGCC
Benefits		Income from sale of power Emission reduction at power plant More efficient than baseline
Additionality		Financial Regulatory Technological Investment
Plant capacity (MW)	500	500
Power production (GWh/year)	3504	3504
CO_2 emissions (kg/kWh)	1.16	0.82
CO_2 emissions (tonnes/year)	3827786	2305895
Initial investment (million $)	835.5	1114.5
Fuel costs (million $/year)	81.780	57.887
Fuel savings (baseline – opportunity) (million $/year)		15.929
Annual O&M costs (million $/year)	20.9	27.9
Income from sale of power @ Rs _____ per kWh ($/year)		
Years of benefit (project life)	30	30
Other benefits		Reduced local emissions

Project opportunity: PFBC power generation

	Baseline	Project Opportunity
Description	Conventional coal technology	PFBC
Cost Components	-	
Benefits		Income from sale of power Emission reduction at power plant More efficient that baseline Saving of coal
Additionality		Financial Regulatory Technological Investment
Plant capacity (MW)	500	500
Power production (GWh/year)	3504	3504
CO_2 emissions (kg/kWh)	1.16	0.89
CO_2emissions (tonnes/year)	3827786	2977167
Initial investment (million $)	835.5	964.5
Other initial costs		
Fuel costs (million $/year)	81.780	62.937
Fuel savings (baseline – opportunity) (million $/year)		12.562
Annual O&M costs (million $/year)	20.9	24.1
Income from sale of power @ Rs _____ per kWh ($/year)		
Years of benefit (project life)	30	30

Project opportunity: renovation and modernization of power plant

	Baseline	Project opportunity
Description	705 MW power plant using coal	Renovated power plant with a capacity of 720 MW
Benefits		Savings in fuel consumption Reduction in the level of emissions
Additionality		Regulatory Technical. Emission
Plant capacity(MW)	705	720
Power production (GWh/year)	4014	4415
CO_2 emissions (kg/kWh)	1.33	1.20
CO_2 emissions (tonnes/year)	5354032	5333840
Initial investment (million $)		84.10
Fuel costs (million $/year)	135.450	134.939
Fuel savings (million $/year)		0.510
Annual O&M Costs ($/year)		55
Years of benefit (Project life)	10	10

Project opportunity: solar thermal power generation

	Baseline	Project opportunity
Description	Conventional coal technology	Parabolic trough system
Benefits		Income from sale of power Total emission reduction Would benefit industrialization in arid zones and provide livelihood for people No use of any natural resources or fuel in power generation
Additionality		Financial Regulatory Technological Investment
Plant capacity (MW)	500	500
Power production (GWh/year)	3504	1007.4
CO_2 emissions (kg/kWh)	1.16	0.00
CO_2 emissions (tonnes/year)	3827786	0.00
Initial Investment (million $)	23394	62748
Other initial costs		
Fuel costs (million $/year)	81.780	0.00
Fuel savings (baseline – opportunity) (million $/year)		81.780
Annual O&M costs ($/year)		
Income from sale of power @ Rs/kWh ($/year)		
Years of benefit (project life)	30	30
Other Benefits		

Project opportunity: replacement of conventional coal technology with wind based power generation

	Baseline	Project opportunity
Description	Power generation using conventional coal	Wind based power generation technology.
Benefits		Savings in cost of the fuel used to generate power Emission reductions
Additionality		Regulatory Emission Technical
Plant capacity (MW)	500	3
Power production (GWh/year)	3504	6.83
CO2 emissions (kg/kWh)	1.16	0
CO2 emissions (tonnes/year)	3827786	0
Initial investment (million $)	835.5	4.96
Fuel costs (million $/year.)	81.78	0.00
Fuel Savings (baseline – opportunity) (million $/year.)		81.78
Annual O&M costs (million $/year)	20.9	0.12
Years of benefit (project life)	25	20

Project opportunity: replacement of electric pumps with wind pumps

	Baseline	Project opportunity
Description	Electric pump with a capacity of 5 HP	Wind-based water pump
Benefits		Reduction in CO_2 emissions Augmentation of drinking water supply options
Additionality		Regulatory Emission
Plant capacity	5HP	
CO_2 emissions (kg/kWh)	1.16	0
CO_2 emissions (tonnes/year)	2.02	0
Initial investment ($)	1178	2321
Other initial costs		
Fuel costs ($/year)	109	0
Fuel savings (baseline – opportunity) ($/yr)		109
Annual O&M Costs ($/yr)	18	71
Years of benefit (project life)	20	20
Other benefits		

Project opportunity: replacement of wet quenching process by dry quenching technology in the iron & steel industry

	Baseline	Project opportunity
Description	Wet quenching technology in production	Dry quenching technology in production
Benefits		Reduction in the level of emissions
Additionality		Regulatory Technical. Investment
Plant capacity	NA	NA
Power production (GWh/year)	0	0
CO_2 emissions (kg/kWh)	NA	NA
CO_2 emissions (tonnes/year)	155977	0
Initial investment (million $)		17.8
Fuel costs (million $/year)	NA	NA
Energy savings (Baseline – opportunity) (TJ)		1819
Annual O&M costs ($/year)	0	535714
Years of benefit (Project Life)	30	30
Other benefits		Better efficiency of operation Better environmental performance

Project opportunity: continuous digester process in pulp and paper industry

	Baseline	Project opportunity
Description	Batch digester	Continuous digester
Cost components		
Benefits		Total emission reduction
Additionality		Financial Regulatory Technological Investment
Plant capacity (tpd)	300	150
Savings in CO_2 (kg/tonne)		700.71
CO_2 emissions (million tonnes/year)		0.903
Initial investment ($/tonne/year)	30.509	
Other initial costs		
Fuel savings (baseline – opportunity) ($/year)		20.96
Annual O&M costs ($/year)	1.525	0.00
Years of benefit (project life)	20	20
Other benefits		Better local environment Less opposition to setting up of these plants Larger quantum of CERs Easy monitoring and measurement

Project opportunity: replacement of standard motors with energy efficient motors in the industrial sector

	Baseline	Project opportunity
Description	Standard motors	Energy efficient motors
Cost components		
Benefits		Meets environmental standards better
Additionality		Regulatory Emission Technical
Capacity (kW)	55	55
CO_2 savings (tonnes/year)		9.092
Initial investment ($)	4220	5893
Other initial costs		
Fuel savings (baseline – opportunity) ($/year)		713
Annual O&M costs ($/year)	Nil	Nil
Years of benefit (project life)	8	8

Future options

The above exercise focuses exclusively on energy sector options. However, it does indicate that the focus in India is primarily on power generation, renewable energy for meeting rural energy demands, and industrial sector interventions. Urban air pollution makes transport sector mitigation options (MRTS, CNG cars and buses) important, but potential CDM projects would have to be designed carefully to minimize transaction costs and ensure additionality.