Paper 8
ENERGY, INDUSTRIES AND COMMERCE

Atul Kumar and Vivek Kumar
TERI, India

Executive Summary

A major political debate in the international climate regime post 2012 is the role of developing countries, especially the major developing countries like China, India, Brazil, Mexico, to name a few. Various kinds of proposals are being suggested o suit the sensitivities and priorities of these countries so that the base of the climate change actions the world over could be broadened. In the same series appears the proposal for sectoral approach.

This paper presents a sectoral analysis of energy and industry sector in India, current status and trends, including somewhat detailed description of the energy efficiency improvement measures across key energy intensive industries. Energy intensity of the industry sector shows a downward trend and some of the recent plants in cement and fertilizer sector rank among one of the top plants in the world. However, the cause of concern is the large number of old plants in which continue to operate so as to meet the increasing demand.

The paper also presents broad GHG mitigation opportunities across different sectors in India with respect to their mitigation potential and costs. Key barriers in implementation of these options include finance/high upfront cost, access to technology/raw material, know how, etc. To overcome these barriers, the required additional resources or support has been discussed under three broad categories viz. Potential financial support mechanisms, Carbon markets and carbon funds, and Technology transfer. The financial support mechanisms may have various dimensions such as support from i) Annex I countries for large-scale technology deployment and diffusion of established technologies, ii) public and private sector funding and investment including facilitation of climate friendly investment choices and iii) venture capital, etc.

Energy an imperative for economic development

Energy is a prime mover of economic growth and development. This is critically important for the developing countries like India where economic development is on the rise. Simultaneously providing adequate and equitable access to basic amenities and services is the immediate priority of the policymakers of the country. Energy will also be required to meet the targets set up by these countries under the MDGs (Millennium Development Goals) adopted at the UN Millennium Summit held in Johannesburg in September 2000 for improving the condition of the world's poorest by 2015. Therefore, only economic development can provide a lasting solution to address the problems of the country (ADB, 2007).

Literature reveals that no country has substantially reduced poverty without massively increasing its use of energy. Electricity, in particular, plays a crucial role in improving levels of human development and quality of modern life (ADB, 2007). This is supported by the relationship between human development and energy consumption from the empirical relation ship between HDI and energy consumption for different countries (UNDP, 2006, ADB, 2007). Over the years, India has made substantial progress in social welfare with the HDI increasing from 0.515, in year 1990 to 0.611 in year 2004 (UNDP, 2006). However, the 126th position of

India in the HDI list reiterates the fact that country has to move upward significantly in human development.

Economic reforms, implemented by successive governments over the past two decades, particularly since 1991, have resulted in the Indian economy maturing in several important respects and integrating much more with the world economy. India has experienced impressive growth rates in the recent past with a GDP growth rate of 9.0% and 9.2% in 2005-06 and 2006-07 respectively (MoF 2007). While this performance reflects the strength of the economy in many areas, it is also true that large parts of population of India are yet to experience a decisive improvement in their standards of living. For example, around 44% of the households In India do not have access to electricity (Census of India, 2001).

Overview of the Energy sector

The Indian energy sector is complex due to the wide variation in lifestyles and use of energy forms among different section of society. Although there has been a gradual increase in the use of commercial fuels, a sizeable quantum of energy requirements (around one third), especially in the rural household sector, is still met by non-commercial energy sources such as fuelwood, crop residue, and animal waste (Planning Commission, 2006a).

Growth in the Indian economy and consequently in the country's energy requirements is increasingly being seen as an important element in the future global energy scenario. At present, India ranks fifth in the world in terms of primary commercial energy consumption, accounting for about 3.9% of the world's commercial energy demand in 2006 (BP, 2007). However, despite the overall increase in energy demand, per capita commercial energy consumption in India is still very low compared to other developed and major developing countries. Furthermore, past trend shows that the energy intensity of economy is reducing continuously (IEA, 2007).

Table 1 presents the sector wise final commercial energy consumption in India during 2001-02 to 2005-06. Final commercial energy consumption has increased from 180 mtoe in 2001-02 to 217 mtoe in 2005-06 at a CAGR of 4.8%. Industry sector continue to be is the highest energy consumer followed by the transport and residential sectors (TERI, 2008).

Table 1: Sector wise final energy consumption (in mtoe)[1]

Sector	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**
Agriculture	14.9	15.3	15.3	15.4	15.1
Industry	76.8	83.6	84.6	88.8	96.2
Transport	33.4	34.2	34.8	36.3	36.5
Residential	24.6	25.9	26.6	29.0	29.5
Commercial	3.5	3.7	3.8	3.1	3.1
Other Energy Uses	8.2	9.2	12.1	16.1	18.7
Non Energy Uses	18.0	16.7	16.4	17.8	17.5
Total	**179.8**	**188.5**	**193.5**	**206.5**	**216.5**

On the supply side, India is relatively well-endowed with both exhaustible and renewable energy resources. Coal, oil, and natural gas are the three primary commercial energy sources. Coal is

[1] Non Energy Uses essentially mean use of energy sources for non-energy purposes such as feed stock in fertilizer and petrochemicals industries.

the largest source of energy accounting for a share of 53 % in the year 2005-06 in the total commercial energy supply. Table 2 presents the domestic production of energy sources (TERI, 2008). However, resource augmentation and growth in energy supply has not kept pace with increasing demand and, therefore, India continues to face serious energy shortages. This has led to increased reliance on energy imports to meet the energy demand and thus increasing the burden on import bill (TERI, 2008).

Table 2: Production of primary energy sources of energy in India

Source	***Unit***	***1970-71***	***1980-81***	***1990-91***	***2000-01***	***2004-05***	***2005-06***
Coal and lignite	MT	76.34	119.02	228.13	336.64	412.95	437.11
Crude oil	MT	6.82	10.51	33.02	32.43	33.98	32.19
Natural gas	BCM	1.45	2.36	18.00	29.5	31.76	32.2
Nuclear power	BkWh	2.42	3.00	6.14	16.9	17.01	17.32
Hydro power	BkWh	25.25	46.54	71.66	74.36	84.61	101.49
Wind power	BkWh	–	–	0.03	1.58	4.49	NA

Note: MT – million tonnes; BCM – billion cubic meters; BkWh – billion kilowatt-hours; NA: data is not available

Realizing the fact that the future social and economic development of the nation is premised on achieving a high rate of economic growth delivered with equity and social justice, the Government of India in its Approach Paper to the Eleventh Five-Year Plan has set several monitorable targets to bring about a general improvement in living conditions of its citizens. The approach paper also emphasizes that rapid economic growth has to be an essential part of the country's strategy (Planning Commission, 2006b).

Given the strong correlation between economic activity and growth in energy and infrastructure, it is evident that energy requirements of the country would increase rapidly. The Integrated Energy Policy report brought out by the Planning Commission estimates that in an 8% GDP growth scenario, India's total energy requirements would be in the range of 1536 Mtoe (million tonnes of oil equivalent) to 1887 Mtoe by 2031 under alternative scenarios of fuel and technological diffusion (Planning Commission, 2006a). Coal and oil are expected to contribute a large part of this energy need. Accordingly, India faces a formidable challenge in meeting its energy needs in a sustainable manner. Concerns with regard to India's energy growth relate not only with environmental concerns at the local and global levels, but also with regard to the availability of reliable and affordable supply of appropriate fuels for each section of the society.

Brief status of key emission intensive industries in India

Industry sector accounted for 44% of total commercial energy consumption in the country during 2005–06, with coal and lignite meeting nearly 60% of total commercial energy consumption (TERI, 2008). Since the industry sector is viewed as central for economic growth, it would continue to play a major role in the overall development of India. The industrialization policies of the country had helped in setting up of several resource–intensive primary manufacturing facilities such as iron & steel, cement, fertilizer, refineries, etc with investment targets being fixed in successive Five Year Plans of the Government of India. The Planners also encouraged various small scale industries, providing huge employment in rural and peri-urban areas. The small scale sector produces close to 7500 items in which 326 items are reserved by the Government of India (MoSSI, 2007) to be exclusively produced by small units.

The industry sector is one of the largest contributors of CO_2 emissions in India, next only to power sector. As per the national greenhouse inventory data for the year 1994 compiled by the Ministry of Environment and Forests, Government of India, the direct CO_2 emissions from industrial sources accounted for nearly 31% of the total CO_2 emissions from the country (MoEF, 2004). Section below presents the status of key energy intensive industries in India.

Aluminium Industry

Aluminium is an essential raw material for modern manufacturing. Aluminium is extensively used in power (for transmission and distribution), transport, construction, and domestic sector. Aluminium is easy to recycle. Aluminium production is highly electrical energy intensive and it requires continuous and uninterrupted power supply. Production of aluminium has two distinct process viz. production of alumina from bauxite ore (Bayer process) and conversion of alumina to aluminium in smelters (smelting process). Smelting process accounts for major share of energy consumed in production of primary aluminium. Two major technologies viz. (1) Pre–baked process and (2) Soderberg process are used for smelting of alumina. Pre–baked process is the energy–efficient process that account for 75% of total installed capacity in India. Electricity cost forms about 40% of the total production costs and hence energy efficiency continues to be a major area of focus for the aluminium industry.

Cement Industry

Cement is a key component of infrastructure development. It is used in construction of Buildings, bridge, road, airport etc. India is the second largest producer of cement after China. It accounts for about 6.5% of global cement production. Indian cement industry uses (1) dry process, (2) semi-dry process and (3) wet process for cement production. The cement industry has witnessed a remarkable improvement in energy intensity with the shift towards the 'dry' production process and increased share of blended cements. The average specific thermal energy requirement for clinker production has decreased over the years. Similarly specific electricity requirement for cement production has also come down. Further more, all the new plants that are being set up are among the most energy efficient plant globally.

Fertilizer industry

Fertilisers play an exceedingly important role in the country's performance in agriculture sector. India produces nitrogenous and phosphatic fertilizers only. Due to unavailability of raw materials, entire requirement of potassic fertilizer is met through import.

Principle raw materials used for nitrogenous fertilizer making are ammonia and carbon dioxide. Production of ammonia is the highest energy intensive process in fertilizer manufacturing, it accounts for almost 80% of the energy consumption in the manufacturing processes of a variety of final fertilizer products. The better feedstock and process technologies together with improved operation and maintenance practices, retrofitting etc. have resulted in significant improvements in energy consumption in ammonia production. Most of the new fertilizer plants that have been set up during the last decade incorporate state of the art technologies.

Iron and Steel Industry

The Iron and Steel sector is one of the largest energy consuming sectors in the Indian manufacturing industry. India is one of the largest producers of steel in the world. Its growth is dependent on demand–driven end–use sectors like infrastructure, automobiles and consumer durables. There are eight large integrated steel plants in the country with a cumulative installed capacity of about 19.3 million tonne and capacity utilization of about 104% in 2004/05.

Technologies used in iron & steel sector include (1) BF–BOF (blast furnace – basic oxygen furnace), (2) Scrap – EAF (Scrap – Electric Arc Furnace), (3) DRI – EAF (Direct Reduction Iron – Electric Arc Furnace), and (4) COREX. Though the specific energy consumption of the Indian integrated steel plants decreased significantly (around 22%) during 1990-1991 to 2003-04 but still it is high as compared to the United state and Japan which indicates the scope of further improvement in energy efficiency (TERI, 2006).

Pulp & Paper industry

The demand of paper and paper products in India has continuously been increasing over the time. However, per capita paper consumption in India is about 5.5 in the year 2003 as against of world average of 50 kg (TERI, 2006). There are about 525 pulp and paper mills with an installed capacity of 6.5 million tonne. The installed capacities of Indian mills vary over a wide range of 5 tpd to 600 tpd. Indian paper mills are categorized into (1) large mills with installed capacity of more than 100 tonne per day, and (2) small mills with capacity less than 100 tonne per day. The small units account for more than 50% production capacity, and characterized by poor energy efficiency. About 80–85% of energy is used for process heating while the share of electricity accounts for 15–20%. More than 80% of electricity used in large wood–based mills is met by cogeneration units.

Most of the paper mills operating in India, particularly small mills, are very old using out-dated technology including plant & machinery. Being protected from international competition for about four decades, Indian paper mills, in general, did not keep up with the technological advancement in the other parts of the world. A few large paper mills have implemented new technologies because of high product quality, international competition, mounting pressure from environmental regulatory, rise in energy prices, etc.

Textile Industry

Textile industry contributes 14% to the industrial production, 4% to the GDP and 16% to the country's export earnings. This sector also contributes to 27% of the national export earnings. Moreover, the textile industry plays a major role in employment generation accounting for about 27% of the total work force of the country (second after the agriculture sector).

There is a wide range of variation in the processes and technologies employed in different factories across India. Composite mills cover complete sets of processes, from raw material to final products, however most manufacturing units tend only to deal with a part of the process. The primary energy inputs in the textile industry are steam and power. The requirement of steam and power varies with the yarn count, yarn productivity, type of fabric (product mix), fabric productivity and extent of wet processing (dyeing and printing). In view of increased mechanization, the energy consumption in the textile industry has also increased. Specific energy consumption of modern textile mills is higher due to replacement of manual labour by electric power. Moreover, there is a trend of shift towards more mechanization.

The energy costs in textile production account up to 17% of total manufacturing costs (ADB, 1998). Therefore, energy conservation has become quite important. Most of the textile units in India have made lot of efforts towards energy conservation on a short and medium term basis. As a result of these efforts, the extent of energy savings reported by many mills varies from 5-

15%. Some of the progressive mills have invested huge amount of money for implementation of long-term measures such as boiler replacement, cogeneration system and changing of process machines, etc. resulting in energy savings to the extent of 20-25%. Moreover, electric energy consumption is expected to continue to rise over time due to increasing automation and higher running speeds for machines.

GHG emission reductions across different sectors - benefits/opportunities and cost/challenges

According to the first national communication of India to the UNFCCC, the aggregate emissions from the anthropogenic activities amounted to 1229Mt of CO_2 equivalent. On a sectoral basis the energy sector accounted for about 61 per cent, agriculture 28 per cent, industrial process 8 per cent, waste disposal 2 per cent and land use and land use change 1 per cent. It should be noted here that the energy related emissions from industries are accounted in the energy sector. The base year for the first national communication had been 1994 and since then the economy has expanded tremendously resulting into many-fold energy demand and GHG emissions.

Various sectors of Indian economy present opportunities for emission reduction and the table below presents a list of such options. The drivers for these options presently are other than climate change and are driven primarily by the energy security and energy prices concerns. However, keeping in view the challenges of climate change and need for significant emission reductions by all the countries as recognized by IPCC and the Bali Action Plan, it becomes important that these opportunities are upscaled several folds and with climate change as the prime driver. The necessary resources for these options could be explored under the mechanisms and framework provided through the multi-lateral environmental agreements, including the UNFCCC. Table 1 below presents a quick listing of such options in the power, industry, transport, and residential and commercial sectors. The table also presents a broad potential of their contribution to addressing climate change as well as their cost categories.

Table 1: Mitigation potential versus costs

Mitigation potential / Cost	**Low**	**Medium**	**High**
Low	Super critical Advanced gas turbine R & M	Small hydro Labeling of consumer appliances Green buildings	Industrial energy efficiency Transport sector interventions (public transport, road to rail & efficiency improvement) Efficient lighting
Medium	Renewable energy options	Ultra super critical power plants	
High		Hybrid vehicle for city transport	IGCC CCS Hydorgen based IC engine for transport

Some of the mitigation options listed above are already taking place in the country. Implementation of medium to high cost implementation options or large-scale deployment of even the low cost options faces various challenges. Some of the common challenges include the following:

- Finance, high upfront cost
- Access to technology, raw material
- Know how, mind set
- Lack of incentives
- Lack of benchmarks, policy directives

With the Indian economy on the rise, not only the energy requirements are burgeoning but also the infrastructure demand across all the different sections of the economy. This will further exacerbate the energy needs and need for other natural resources. There is an urgent need for large-scale deployment of the technologies that are already available. Examples of some of these in the power sector can be coal based power generation using the super critical boilers or the renovation and modernization of the old power plants. As mentioned earlier, this would require substantive financial support. Financial mechanisms for their large-scale implementation need to be devised on an urgent basis and the following section covers discussion on what may be various potential sources.

In addition to deployment of existing technologies, there is also need to progress the research on other high potential GHG emission reduction technologies. Further, some of the technologies that may have been established in labs, their entry into the field should be encouraged on an urgent basis by laying down necessary enable environment.

Additional resource requirements - role of financial support, market mechanisms, technologies etc.

Most of the GHG emission reduction initiatives require high upfront investment and there is a need to explore various possible options to support such actions in developing countries. As mentioned earlier, financial support and access to state of the art technologies will significantly upscale the contribution of developing countries in addressing climate change challenge.

Potential financial support mechanisms

The financial mechanisms may include a wide range of options, including the support from Annex I countries as envisaged in the UNFCCC, bi-lateral support from countries and venture capital fund.

Financial support from Annex I countries for large-scale technology deployment and diffusion of established technologies

The need for large-scale deployment of established technologies in developed and developing countries has been well recognized for addressing climate change meaningfully. Cooperation among countries with regard to transfer of technologies can play an important role in the promotion of these technologies by a broad set of countries. Developing countries, due to their weak technological and financial capacities, depend more so on developed countries for their climate change mitigation actions. Realizing this differential capability of countries, UNFCCC called for Annex I countries taking all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties.

Mobilization of public and private sector funding and investment including facilitation of climate friendly investment choices

The role of public sector in the transfer of environmentally sound technologies (EST) becomes particularly important, as there happen to be weak pricing mechanisms or policies to incorporate environmental costs. The public sector typically engages in long-term and infrastructure investment projects. Initiatives promoting technology transfer have mostly taken the shape of ODA contributions. Overall, a downward trend has been seen in ODA, both in absolute terms and as a percentage of funding for projects.

Private sector initiatives essentially require strong macroeconomic and environmental framework to adequately support ESTs, so that they are financially viable. Even if this is the case, it may not cover other aspects of concern to financial markets such as the significance of climate change to their businesses or the risks involved. Private sector finds it most difficult to finance high-risk and long-term projects—the very nature of ESTs (low operating costs and high up-front expenditure).

Venture capital

For encouraging technology research and development, role of venture capital could be explored. Venture capital for technology innovation is a special type of financing arrangement as its provisions are customized to the needs of the receiver and the skills of the provider. Use of venture capital through interaction between technologists, entrepreneurs would contribute towards taking the new technologies for climate change to the market. These funds could be used for purposes carrying high risks and hence the term lending structure of these funds have to be designed in such a way so that the provider of the venture capital knows that the funds would be used for high – risk investments. So the funds would be ready to accept the high risks of failure, which has to be reflected in the interest rate structures (cost of capital). The returns from these funds could also be high and hence the providers of venture capital for climate change has to work in a high risk – high return framework of financing.

Carbon Markets and Carbon Funds

The carbon markets – CDM, JI, EUETS, etc. provide a boost to introduction of clean and environmentally sound technology-based projects. CDM, which is the presently available carbon market for India, by design envisaged technological transfer to developing countries from Annex I countries and financial resources through carbon trading. Participation in CDM provides an opportunity to developing countries to get these resources for complimenting their sustainable development efforts.

India has been quite proactive in the CDM field and has the distinction of having maximum number of projects registered with the CDM Executive Board. More than 500 million CERs are expected out of these projects and amounting to more than 18000 million USD.

Continuity of the carbon market post 2012 and a sizeable market by way of deep emission reduction commitments by Annex I countries will encourage further actions. This will also lead to high carbon prices and encourage implementation for more and more clean energy measures besides triggering innovation towards a low carbon development. So far, only the EUETS (European Union Emission Trading Scheme) is the active carbon market. Some voluntary initiatives have also been started but the real drive for low carbon development will come only when there is a sizeable and sustained carbon market and the carbon price is significantly high.

Another means to support low carbon development can be sectoral/programmatic CDM. So far, CDM projects have been individual projects whereas there is a need that sectoral activities or activities under a policy or program of government of India are transformed into CDM projects. This will have dual benefit of sectoral improvements and environment and climate change.

Technology transfer

India has been able to adopt many clean technologies/initiatives across various sectors of the economy. However, keeping in view the large size of the economy, these interventions have a little impact and all these measures need to be up—scaled several fold. Keeping in view the important contribution of technologies, it is important that it is considered as an urgent issue. There is a need for transferring state of the art technologies to developing countries and also developing new and more efficient technologies.

Technology transfer should be considered in its true sense i.e. not merely the transfer of the equipment but also training and capacity building on the know how. Further there would also be need for customization of the technologies to adapt to India condition and this should be an integral part of any collaboration on technologies.

Intellectual property rights pose a major barrier in transfer of technologies, at least on technology diffusion. In light of this, there have been many suggestions in the recent past to address IPR as a challenge in efficient transfer of technology that is useful for mitigating climate change. These range from trying out compulsory license to joint ownership to technology acquisition and knowledge repository funds. Joint research and development is suggested to be another means to address the issues related to intellectual property rights. The viability of such proposals however needs to be examined through some pilot projects.

Conclusion

India still faces large development challenges, and this paper presents an overview of some of those. Even though economic development is the primary concern of the country, many climate change mitigation activities are being undertaken, albeit often with a view to addressing energy saving and security issues, Furthermore, a bottom up analysis of various sectors shows that the Indian economy offers significant opportunities for GHG emission reductions even as it continues to grow.

A broad framework for clean investment would encourage the developing countries to frame appropriate policies and initiate suitable programs having linkages with such a framework. Further availability of funds through the options mentioned above would help in deployment and diffusion of the existing technologies to a great extent. Availability of such a Fund may also trigger adoptions of certain technologies at the threshold of economic viability if the Fund can support the upfront cost.

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