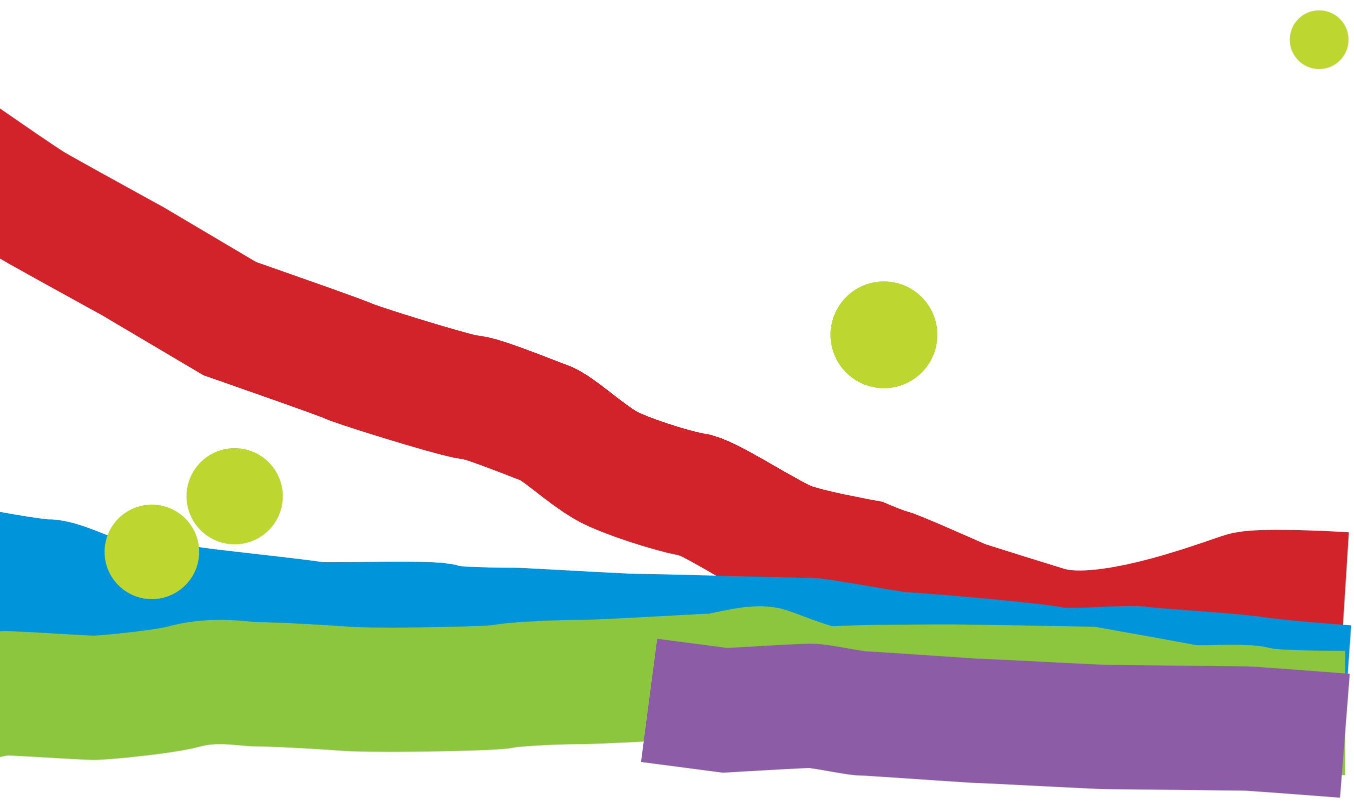
An overview of Indian Energy Trends:

Low Carbon Growth and Development Challenges



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September 2009

प्रयास

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Cover concept:
Despite much lower responsibility for climate change and lower capability to mitigate its effects, India and China have a much higher contribution (about 10 percent) to electricity capacity from renewable energy technologies compared to the US which has only four percent. In addition, energy intensity of the Indian economy has been low and continues to fall, reflecting a fairly disciplined growth.

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List of Abbreviations:

APDRP:	Accelerated Power Development and Reform Programme
APM:	Administered Price Mechanism
BEE:	Bureau of Energy Efficiency
BHEL:	Bharat Heavy Electricals Ltd.
CEA:	Central Electricity Authority
ACESA:	American Clean Energy and Security Act
CFL:	Compact Fluorescent Lamps
CNG:	Compressed Natural Gas
CO_2:	Carbon Dioxide
COP:	Conference of Parties
DSM:	Demand Side Management
EA 2003:	Electricity Act 2003
ECBC:	Energy Conservation Building Code
EIA:	Energy Information Administration
ESCo :	Energy Service Company
EU:	European Union
FAO:	Food And Agriculture Organization
FYROM:	Former Yugoslav Republic of Macedonia
GDP:	Gross Domestic Product
GHG:	Greenhouse Gases
GJ:	Giga Joules
GW:	Giga Watt
GoI:	Government of India
HDI:	Human Development Index
IEA:	International Energy Agency
IEP:	Integrated Energy Policy
IGIDR:	Indira Gandhi Institute of Development Research
JNNURM:	Jawaharlal Nehru National Urban Renewal Mission
KWH:	Kilo Watt hour
LBNL:	Lawrence Berkeley National Laboratory
LW-CS:	Lieberman-Warner Climate Security
LDV:	Light Duty Vehicle
LPG:	Liquefied Petroleum Gas
MNRE:	Ministry of New and Renewable Energy
MOP:	Ministry of Power
MW:	Mega Watt
MoPNG:	Ministry of Petroleum and Natural Gas
MoSPI:	Ministry of Statistics and Program Implementation
NAMA:	Nationally Appropriate Mitigation Actions plans
NAPCC:	National Action Plan for Climate Change
NELP:	New Exploration and Licensing Policy
NMEEE:	National Mission on Enhanced Energy Efficiency
NSSO:	National Sample Survey Organization
NUTP:	National Urban Transport Policy
OECD:	Organization for Economic Co-Operation and Development
PCRA:	Petroleum Conservation Research Association
PJ:	Peta Joules
PLF:	Plant load factor
PPP:	Purchasing Power Parity
PV:	Photovoltaic
R&M:	Renovation and Modernization
RE:	Renewable Energy
RGGVY:	Rajiv Gandhi Gramin Viduytikarn Yojana
RPO:	Renewable Purchase Obligations
SIPS:	Special Incentive Package Scheme
SMP:	Sustainable Mobility Project
SUV:	Sport Utility Vehicle
T&D:	Transmission and Distribution
TPES:	Total primary energy supply
US:	United States of America
USDOE:	Department of Energy, United States
VAT:	Value Added Tax
WEO:	World Energy Outlook
WRI:	World Resources Institute

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Executive Summary

India's contribution to climate change presents a daunting challenge for development. India is the fourth largest emitter of global greenhouse gas (GHG) emissions after China, the United States and Russia, contributing about 5 percent of total emissions in 2007. But it is also home to a third of the world's poor. India's per capita CO_2 emissions of 1.3 tons are well below the world average of 4.4 tons. Even by 2020, with almost a fifth of the world's population, its share is expected to rise to only 7 percent, according to the International Energy Agency's Reference Scenario. The Indian government has been uncompromising in its aversion to allowing climate considerations to slow its economic growth. Yet, within the country, growth has largely benefited the middle and upper classes, with hundreds of millions remaining in poverty.

In light of the urgency for a global turnaround in emissions before 2020, and the failure of Annex I countries to reduce their own emissions despite the Kyoto Protocol, it is imperative that developing countries expand their economies at diminishing rates of carbon intensity, preferably with assistance from the Annex I countries. Indeed, preventing atmospheric GHG concentrations from reaching dangerous levels will require drastic reductions in the emissions of Annex 1 countries and dramatic curtailment in the growth of non-Annex 1 countries' emissions. The need for a truly two-sided bargain means that India too must find a way to reduce its emissions soon, though how soon and by how much is still a matter of negotiation rather than of science. As Copenhagen fast approaches, however, international negotiations appear to be stymied over the adoption of firm mitigation commitments for Annex 1 countries and suitably robust measures and actions for non-Annex 1 emitters such as China and India.

This paper takes the perspective that a deeper, comparative understanding of economic trends and contexts across countries is necessary to provide a constructive basis for engagement. In this vein, it is important that the international community understand in greater detail India's energy needs, trends and policies to see where India currently stands with respect to climate security. This paper provides an overview of India's energy-related carbon dioxide emissions, its drivers and future outlook.

Our review suggests three main conclusions:

- India's energy-related emissions need to grow to alleviate poverty and raise living standards (Figures 2, 3), but the extent of this need is uncertain. Business-as-usual trends do not favor the poor's development, nor do they sufficiently exploit co-benefit opportunities between climate mitigation and equitable development.
- Despite reliance on coal, India is on a low carbon growth path due to low and declining energy intensity (Figure 5), and significant growth in carbon-free electric capacity (Figures 17, 18). Some of the key drivers include high industrial energy prices (Figures 6, 12), energy efficiency improvements in select industries, and inherently low-carbon lifestyle patterns, such as vegetarianism (Figure 14) and high use of non-motorized modes and public transportation.
- In the near future, the recent trends of declining energy and carbon intensity seem likely to continue. However, they are weakened by unsustainable patterns of development, such as high passenger vehicle growth. Government policies offer mixed support for these trends, for example, with promising initiatives in demand reduction and renewable energy growth on the one hand, but continued neglect of persistent inefficiencies in electricity supply on the other.

Some of the features of India's energy economy that contribute to its relatively low carbon intensity in comparison to the US and China merit highlighting:

- Renewable energy's share of total electric capacity is more than twice that of the US, and India is among the top five countries in renewable capacity.
- India's carbon and energy use per unit of GDP are both already below that of the US and China, and seem to be on a decreasing trend.
- India had about 12 vehicles per 1000 people in 2007 compared to over 800 in the US. Bus, rail and non-motorized modes of transportation continue to have the largest share of passenger travel, unlike the US, where substantially more carbon-intensive modes such as private automobiles are dominant.
- Industrial electricity tariffs are the highest in the world, on average. Gasoline and diesel prices are higher than those in the US and China, even in market exchange terms.
- Indians consume nearly 1/11th of the meat eaten by an average Chinese and 1/25th of that eaten by an American, implying correspondingly lower greenhouse gas emissions associated with the sector.

Emissions Growth and Development

India's low emission levels in part reflect high levels of poverty. Nearly one in two Indians has little or no access to sanitation, clean drinking water, adequate housing, health care, and modern energy services. Countries exhibit a strong correlation between Human Development and electricity consumption at low to moderate levels of development, making it quite clear that India too should expand its access to electricity. However, the gains from recent growth in the sector have not flowed proportionately to the poor. For example, in 2005 the bottom 40 percent still consumed only 13 percent of electricity demand. The World Bank estimates that despite declining poverty rates, the absolute number of poor has hardly reduced, if at all, in the last few decades.

The emissions impact of more inclusive economic growth is unclear. With an emphasis on equitable growth, it is possible for India to widen access and meet basic needs of the poor with only a minor cost in carbon terms. However, raising overall living standards, as China has shown in the last few decades, will entail economic growth going hand in hand with a substantial increase in emissions unless there are concerted policy efforts to address poverty alongside a dramatic shift towards cleaner forms of energy.

Low Energy Intensity

Of the three sectors of the economy reviewed – industry, transport, and residential - industrial energy intensity is on a declining trend. Energy use in the residential and transport sectors were found to have relatively low intensity in comparison to the US, EU and China.

Industry's declining energy intensity is driven by a number of factors, including structural shifts in the economy towards less energy intensive activities, and efficiency improvements in energy-intensive industries. Because of the rapid growth of services at a rate well above industry growth and overall GDP, its contribution to the economy has grown from 44 percent in 1990 to 52 percent in 2005. If growth in services continues to outpace that of industry, energy intensity will continue to decline. Relatively high industrial energy and electricity prices have also disciplined energy growth, resulting in a steady reduction in the energy intensity of industries.

Government policy has begun to, and in the near future will likely, further drive industrial intensity downward and also reduce residential energy intensity. The Indian government, spearheaded by the Bureau of Energy Efficiency (BEE), launched a series of energy efficiency programs that has grown into an impressive suite of policies and institutions. The adoption of these programs by industry has begun to gather momentum, albeit so far as a result of voluntary efforts. They include standards and labeling programs for appliances, building codes, and industrial process efficiency targeting. They are expected to culminate into a National Mission on Enhanced Energy Efficiency (NMEEE), which includes innovative programs such as mandatory targets and tradable efficiency credits (similar to a cap and trade), capacity building, and financial and risk support.

The transportation sector in India is responsible for only about 15 percent of total commercial energy consumption, in contrast to the global picture, where transportation makes up about a quarter of total energy demand. This is driven by a high load factor and low per capita count for passenger vehicles, dominance of two-wheelers with growing efficiency, relatively high fuel prices, high use (up to three-quarters of passenger demand) of bus, rail and walking for personal transportation, and relatively low commuting distances in dense urban living spaces. The freight energy intensity in India also compares favorably with the US and China, again due to the high share of rail. Nevertheless, while starting from a relatively small base compared to developed countries, current trends in transportation use are not favorable to climate. Shares of private passenger vehicles and commercial trucks are rising rapidly at the expense of public transportation and rail freight, respectively. Recent shifts in policies that promote urban public transportation and railway freight corridors, if implemented properly, can dampen this rise.

The typical Indian lifestyle even in middle class settings encourages relatively low household energy consumption. According to one study, households in India have one-third the energy intensity of American households with the same expenditure – adjusted for purchasing power parity. The high density of urban spaces forces people to live in small homes, which take less energy to build and to cool. Twenty nine percent of India's urban population lives in homes of less than 540 square feet. Despite growing meat consumption, India's aggregate meat consumption is a mere fraction of that of the US and China. The carbon impacts of the meat industry are known to be significant, not just from its high energy intensity, but even more so from its land use impacts. The Food and Agricultural Organization (FAO) estimates that direct and indirect emissions (including land use change) from the livestock sector contribute 18 percent of global GHG emissions.

Low Carbon Intensity

Renewables have become an integral part of India's growth strategy, which is driven by the country's enormous electricity supply shortages and natural resource limitations. The government has actively promoted renewables since the 1990s, as it has all other fuels, including hydro, natural gas, coal and nuclear. While India has consistently underachieved in its targets for coal and hydro growth, it has consistently overachieved in its targets for renewables. Over two thirds of renewable capacity additions have come from wind power (~10 GW), which has grown at an annual rate of 26 percent since 2000. This is in spite of the fact that India has unfavorable wind resource conditions in comparison to USA, EU and China. Since 2000, India has added 14.4 GW of hydro-power capacity. This trend is likely to continue. The Indian government proposes to support 20GW of solar capacity by 2020. Seventeen states, which account for roughly 92 percent of the power consumed in the country, have Renewable Purchase Obligations (RPO) in place, which range from a few percent to 20 percent by 2012.

Natural gas, a cleaner fuel than coal, has also grown to almost 10 percent of India's installed base. The government has actively promoted participation of multiple players in exploration, project development and transportation. Since the inception of this policy, there have been more than 100 hydrocarbon discoveries, with most being natural gas finds totaling over 30 trillion cubic feet. India has also established an independent regulator to oversee downstream gas pricing. While the government envisages a tenfold increase in gas supply, significant uncertainty surrounds the likelihood of this achievement as a result of technical, financial and institutional barriers.

Future Outlook

These positive trends in carbon intensity notwithstanding, significant opportunities remain to continue to drive down carbon intensity and to reduce inefficiencies in the economy. The specific energy consumption in industries varies widely and offers substantial potential savings, if the best available technologies are widely implemented. Despite the growth of renewables, the carbon intensity of electric supply is one of the highest in the world, due to the reliance on and low efficiency of coal plants and inefficient distribution. Demand for air-conditioning and other appliances in the residential and commercial sectors is likely to push electricity demand to high levels, straining the sector as a whole. A legacy of highly subsidized, unmetered supply to farmers has encouraged inefficient resource use and led to financial losses. The growth of passenger vehicles in dense urban areas has worsened local air and noise pollution, accident fatalities and congestion. The continued reliance on traditional biomass cook stoves results in mortality from indoor air pollution, and, as recently found, adds to black carbon that causes short-term spikes in global warming.

The government is yet to generate a coherent long-term strategy to put India on a path of sustainable development that improves the living conditions of the bulk of its population. Considerable scope remains to exploit mitigation co-benefits from policies in transportation, household energy use, and manufacturing. Public transportation in smaller cities, improved safety for non-motorized modes, off-grid low-carbon electricity systems, cleaner cook stoves, and upgraded networks for utility service delivery are few of the areas where concerted policy efforts can bring about more equitable growth with lower carbon emissions. Making these improved services affordable to the poor will remain an unavoidable consideration for successful policy implementation.

International climate negotiations would be better served by a more constructive dialogue that is structured around identifying and exploiting these opportunities for sustainable and equitable development, within the broader context of fairness in allocating global mitigation burdens. Considerable research within India is needed for this effort.

Introduction

As momentum builds towards the COP15 conference in Copenhagen in December, attention has been directed to developing countries' preparedness to undertake mitigation with technical and financial support from the North. The Bali Action Plan in 2007 called for participating countries to develop Nationally Appropriate Mitigation Actions plans (NAMAs) that lay out measurable, reportable and verifiable actions. China has received significant attention for its explosive growth, but also more recently for its domestic actions to promote low carbon development. India, on the other hand, is seen as a lurking giant, with a comparable population but less than a third of China's emissions and with about half its economic output. India's strong resistance against compromising its development goals and undertaking mitigation unassisted has led to its reputation as "obdurate" and "unhelpful".[1] However, this portrayal masks a number of trends, economic characteristics, as well as policies and that align favorably with mitigation.

This paper presents an overview of trends in energy and carbon intensity in the Indian economy, with some insights into their drivers and ongoing policy initiatives in the energy sector that will benefit low carbon growth. While we emphasize signs of optimism, we also indicate some key hurdles and policy shortcomings, both in meeting India's development objectives and in disciplining emissions growth. Our primary aim here is to provide a balanced and insightful characterization of the carbon impacts of current economic trends, and not a rigorous critique of policy. This paper complements other studies of abatement potential and opportunities by providing an assessment of India's starting point – the context of its state of development, future needs and current policy direction.

This paper is organized along the lines of a traditional decomposition of any economy's emissions profile through an examination of income growth, the energy intensity of income, and the carbon intensity of energy use. We are primarily concerned with energy-related carbon dioxide emissions, which comprised 66 percent of India's GHG emissions in 2005. We do not address methane emissions from agriculture, which contributed 30 percent of GHG emissions in 2005. Methane emissions have grown at 1.6 percent from 1990 to 2005, as compared to 4.6 percent for CO_2, resulting in a general decline in its relative share.[2] We also do not specifically analyze trends in government energy use, although we recognize its importance and the need for independent analysis of its trends. We indirectly give due consideration to black carbon and its effects from biomass combustion by commenting on trends in household fuel use, though we do not specify its impacts and trends. Finally, we did not have the scope to sufficiently address other local environmental and social impacts of energy sources. This is a significant undertaking that merits consideration alongside climate change.

In Section 1, we discuss the context for the relationship between climate mitigation and development in India. In Section 2, we discuss energy intensity trends and their drivers, including energy efficiency. In Section 3, we discuss carbon intensity, focusing on trends in the fuel mix of electricity production. In the concluding section, we share some thoughts on the future outlook for climate mitigation in India.

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1 Melting Asia, The Economist, June 5, 2008.

2 Climate Analysis Indicators Tool, World Resources Institute.

I Climate and Development

The world is unmistakably on a path towards dangerous interference with climate change; what remains to be determined is how much we can limit the damage. To date, the rate of progress is disheartening. More than a decade after the Kyoto Protocol was signed, the annual emissions of Annex-I countries that pledged to reduce emissions by about 5 percent below 1990 levels have instead increased by over 15 percent. In the United States, the successful implementation of the American Clean Energy and Security Act's (ACESA) proposed cap-and-trade program and all its complementary requirements (if ratified) would bring its emission levels to those envisioned by the Kyoto Protocol only by 2020.[3] Since cumulative emissions cause climate change, it would take substantially longer to offset the increase in emissions of these last two decades. For example, a study of the recent (but less aggressive) Lieberman-Warner Climate Security (LW-CS) Bill shows that with the Bill's successful implementation it would take until 2034 for the US's cumulative emissions to reach the level effectively targeted by Kyoto in 2012.[4]

Notwithstanding the need for the Annex I countries to adopt and meet more stringent targets, the urgency of the climate problem makes it now imperative that *all* nations contribute to controlling GHG emissions. But climate mitigation and development must go hand in hand. The challenge in developing countries is to grow responsibly, by actively seeking opportunities to dovetail climate mitigation and development objectives.

The Development Challenge

The population of the world's poor decreased from 1.9 billion in 1981 to 1.4 billion in 2005, with nearly this entire reduction taking place in China. Most of the world has not achieved such dramatic reductions in poverty. The population of the world's poor[5] outside China has remained at about 1.2 billion since 1981, despite a reduction in percentage terms.[6] The World Bank projects that by 2015 this number would reduce only to 1 billion.

Of the 1.2 billion poor in 2005, over a third live in India, who comprise 40 percent of the country's population.[7] Raising the living standards of almost half a billion people to decent levels, let alone to those enjoyed by middle-income families, remains a daunting challenge. Almost half of rural India lives in houses made from biomass, mud or unburned bricks, with little or no sanitation and poor access to drinking water. Over 70 percent of India's population relies on traditional fuels (such as biomass) to cook. Over 40 percent of India's population lacks electricity access and use kerosene for lighting. Only one-sixth of those using electricity consume over 100 kWh per month (Figure 1), compared to the average US household consumption of over 900 units per month. The per capita consumption of electricity of India at 481 kWh is less than a fifth of the world average of 2,596 kWh[8]. Widening access and meeting other development goals will, therefore, entail a substantial increase in generation capacity, even with improvements in utilization efficiency.

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3 World Resources Institute, www.wri.org/usclimatetargets

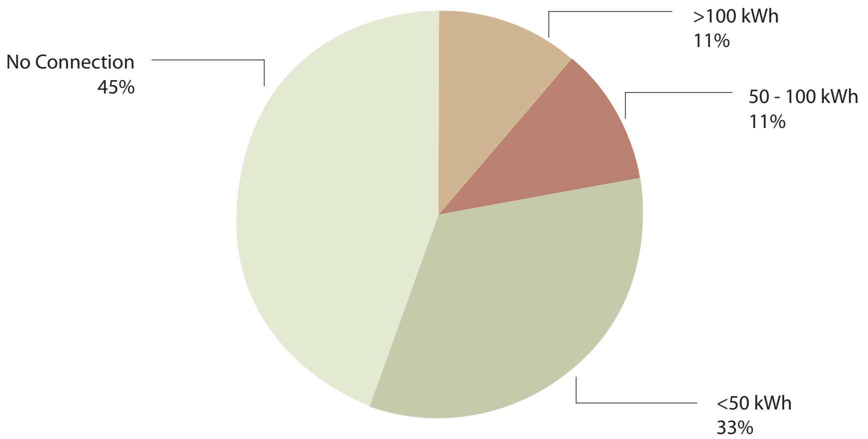
4 Singh et al. 2009. Climate Change: Separating the Wheat from the Chaff, Economic and Political Weekly.

5 The World Bank's most recent definition of the poor is those who live below $1.25 a day, in 2005 prices.

6 World Bank, India, 2008 (http://go.worldbank.org/DQKD6WV4T0)

7 The percentage living below $1 per day declined by 10 percent to 267 million between 1981 and 2005, implying a substantial population lives in conditions marginally above this level of deprivation.

8 EarthTrends, World Resources Institute (http://earthtrends.wri.org/text/energy-resources/variable-574.html)

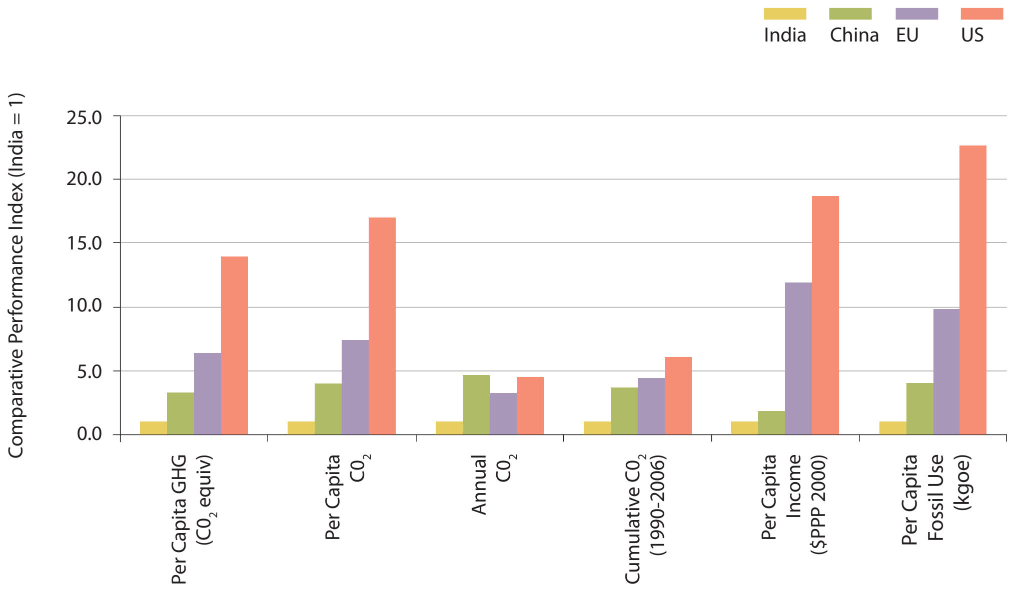


Source: Prayas Energy Group, India

In comparison, an average household in the US consumes over 900 kWh per month.
The lowest US state average was 530 in 2007

Figure 1: Distribution of Household Monthly Electricity Consumption (2005)

India's emissions mirror its average income level. Despite being the second most populous country in the world, India has less than a quarter of CO_2 and total greenhouse gas emissions of the leading emitters of the world, China and the United States, in both annual and per capita terms (Figure 2). India's per capita CO_2 emissions are almost a third of the world average of 4.4 tons. The International Energy Agency (IEA), in its Reference scenario, projects that India's emissions will grow at about 4 percent per year, contributing less than 7 percent of global CO_2 emissions by 2020 (though India is home to almost a fifth of world's population).[9]

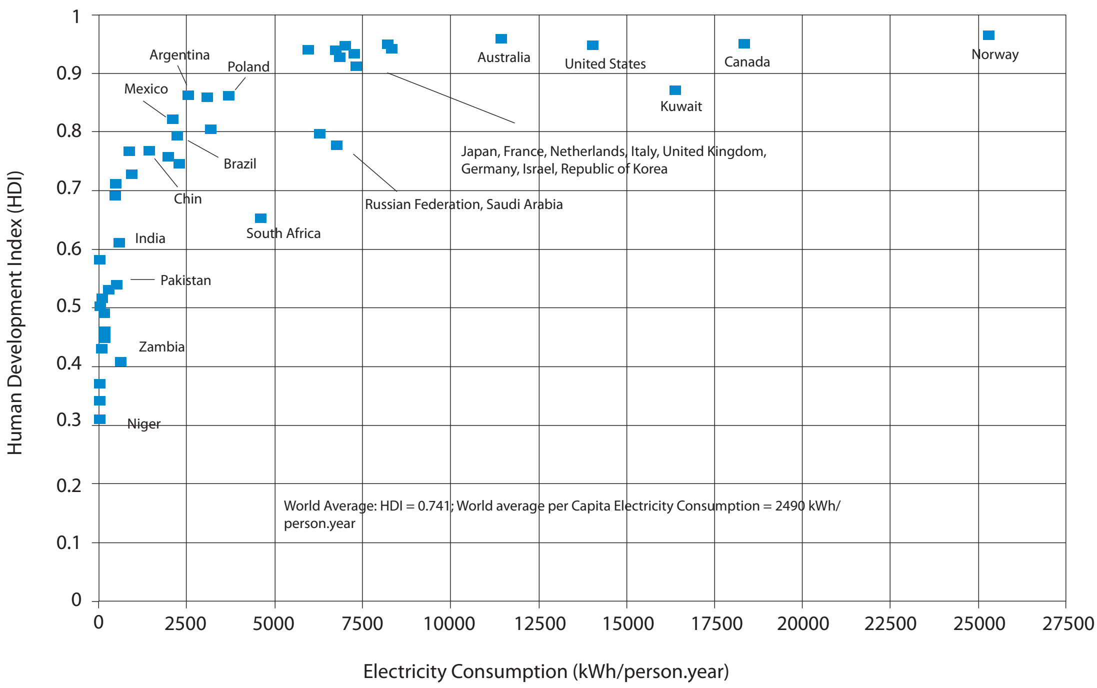


Reference year 2006
Sources: WRI, European Environmental Agency, US Energy Information Administration, International Monetary Fund, BP Statistical Review 2009

Figure 2: Climate and Development Indicators: India, China, US and EU

9 International Energy Agency, *World Energy Outlook*, 2008.

Particularly in the transition out of poverty, countries' energy use and resulting carbon emissions are strongly correlated with income, although the intensity of energy and carbon use can condition this growth[10]. In particular, at low levels of development, small increases in energy use are associated with large increases in the Human Development Index (HDI) (Figure 3). Among wealthy countries, however, large increases in energy use are associated with very small changes in HDI.



Source: Dr. Steve Chu, Department of Energy, US

Figure 3: Human Development Index and Electricity Consumption

Indeed, the need for emissions growth to provide the minimum energy requirements to India's poor is essential, yet modest, relative to developed countries' emission levels (See Inset: Carbon Impact of Poverty Alleviation).

This income disparity needs to be taken into account while developing a mitigation burden-sharing agreement. As the philosopher Henry Shue and others have argued, luxury emissions and not subsistence emissions should be the appropriate target of emissions reductions[11]. When one explicitly accounts for this difference, the relative burden of India, and of less developed countries, is small, and is most likely triggered only beyond 2020. For example, a recent proposal for a burden-sharing regime for climate mitigation based on countries' cumulative emissions since 1990 and their wealth requires that the US bear over 29 percent of the global mitigation requirement in 2020, while India contributes about one percent (Figure 4).

10 Note that correlation does not necessarily imply causality - causality is likely to be bidirectional. See Alan D. Pasternak, "Global Energy Futures and Human Development: A Framework for Analysis," UCRL-ID-140773, Lawrence Livermore National Laboratory (USDOE), October 2000, http://www.llnl.gov/tid/lof/documents/pdf/239193.pdf.

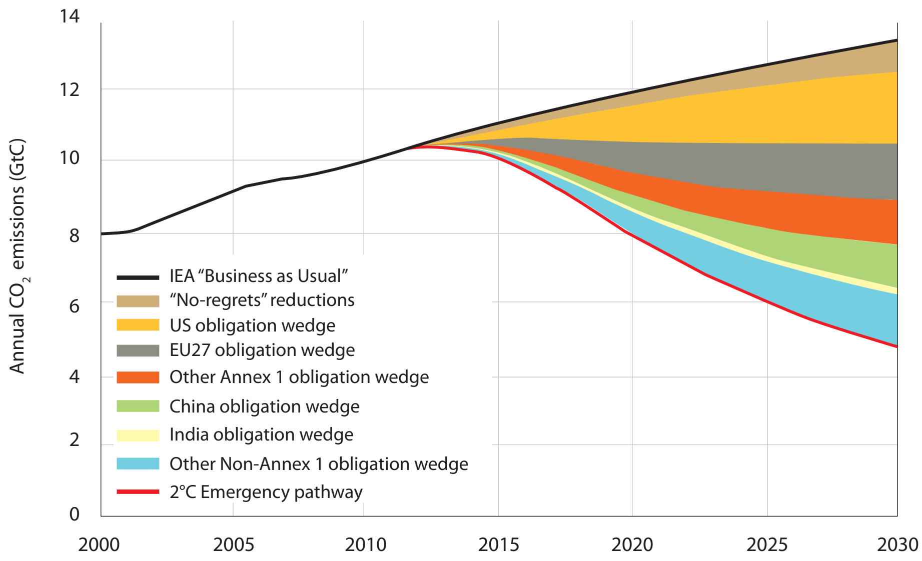
11 Henry Shue, 1993. Subsistence emissions and luxury emissions. *Law & Policy.*

The Carbon Impact of Poverty Alleviation

Over 450 million people in India live below $1.25 a day, the World Bank's global poverty threshold. Over 400 million have no access to electricity. Will bringing these people out of poverty and providing them with modern energy services carry a heavy price for climate?

Providing the poor with minimum energy services requires less than 1 ton of CO_2 per person.[12] This includes electricity for lighting, charging batteries, fans for air cooling, watching TV, cooking with gas and driving a motorized vehicle. The emissions required to provide these services to the entire world's poor of 1.4 billion are equivalent to only a quarter or a third of the American or EU current annual CO_2 emissions, respectively.

The electric capacity required to provide India's 450 million poor with the basic electricity services share of this minimum is less than 8 percent of the US electric supply.



Source: Greenhouse Development Rights, EcoEquity

Total global mitigation requirement, divided into "national obligation wedges" showing the shares that would be borne by particular nations (or groupings).

Figure 4: Global Mitigation Burden Allocation – based on Capacity and Responsibility

A development-sensitive view of burden-sharing across countries does not imply growth should be unconditional or that mitigation and development inherently conflict. Furthermore, all countries should pay attention to the likelihood of getting locked into unsustainable technologies and patterns of development that will make it harder to reduce emissions later. A closer look within India, as would be the case in many developing countries, reveals inequitable growth and many opportunities for mitigation co-benefits.

12 Chakravarty S, et al. 2009. Sharing global CO_2 emission reductions among one billion high emitters. *PNAS Early Edition*.

While India needs to grow, such growth will not contribute sufficiently to development unless it is inclusive and prioritizes the needs of the underprivileged. India has a mixed record on this front. While its poverty rate has declined since 1981, absolute poverty and income inequality have stayed roughly the same or increased.[13] Current trends do not suggest drastic reductions in poverty of the kind that appear to have been achieved in China.[14] India may therefore need to deviate from its business-as-usual trajectory to truly alleviate poverty.

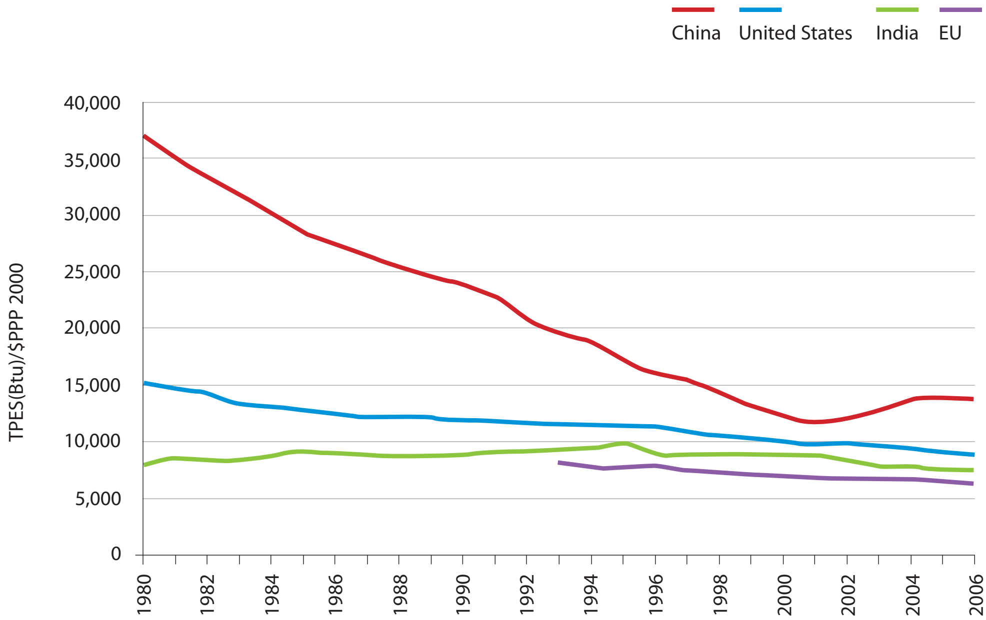
Whether or not India pursues explicit policies toward climate mitigation, several of its development objectives present opportunities for low carbon growth, such as energy security (e.g., promoting alternative fuel sources), economic efficiency (e.g., energy efficiency and conservation), and local environmental protection (e.g., clean cook stoves). Recent development trends confirm this overlap, and demonstrate that some aspects of current development trends and policy initiatives put India on a low carbon trajectory. These trends are discussed in the next sections. There are also important areas where growth, equity and environmental concerns can coincide, but where policy has failed to give adequate attention. These are addressed in the concluding section.

13 According to the World Bank, India, the population living below $1 a day decreased from 1981 to 2005, but increased for those living below $1.25 a day.

14 As reflected in India's achievement of emissions reductions, poverty reduction or other UN Millennium Development Goals by the IEA, World Bank and UN respectively.

II Energy Intensity

The energy intensity of the Indian economy has been historically low and has continued to steadily decline since the mid-nineties (Figure 5). This excludes the use of traditional fuels (such as biomass), and therefore reflects primarily energy use in industry, transportation and agriculture.



Source: Energy Information Administration, US Department of Energy (data for a few countries from EU unavailable before 1993)

Figure 5: Energy Intensity Trends – India, China, US and EU

A clear decoupling between total primary energy and GDP growth is evident since 1990. As per the analysis by De la Rue du Can et al, over the period 1990 to 2005, GDP had multiplied by a factor of 2.3 while energy consumption had by only 1.9.[15]

The overall trend of falling energy intensity is driven by a number of factors, including structural shifts in economic activity towards services and efficiency improvements in energy-intensive sectors like industry and transportation.

With development, agriculture's share of economic activity has been substituted by growth in industry and services. These structural shifts exert opposing influences on energy intensity. Industry has an energy intensity that is about tenfold that of agriculture, while services have an intensity that is about a third of agriculture.[16] Because of the explosive growth of services at a rate well above industry growth, its contribution to the economy has grown from 44 percent in 1990 to 52 percent in 2005.[17]

15 De la Rue du Can et al. 2009. Residential and Transportation Energy Use in India: Past Trend and Future Outlook, Lawrence Berkeley National Laboratory.

16 International Energy Agency, *Better Energy Data for Better Energy Policy, Developing indicators of Energy Use in India,* Feasibility Study Report –Draft, Workshop on Energy Indicators for India: Policies, Technical Issues and Data, April 2002.

17 World Development Indicators, World Bank, 2007.

In the future, if growth in services continues to outpace that of industry, energy intensity will continue to decline. GDP's share of services in India of 53 percent in 2005 stands at about the average for low/middle income countries. However, the global average is 69 percent. Some wealthier developing countries also have higher service shares, such as Brazil with 65 percent.[18]

The following sub-sections describe the efficiency improvements, their drivers and the likely future trends in the industrial, transportation and residential sectors of the economy. We give particular attention to the electricity sector, wherein we also discuss the efficiency of electricity consumption in agriculture.

A) Industry[19]

Industry contributed 26 percent of GDP and consumed 36 percent of final energy consumption in 2005 (De la Rue du Can et al, 2009). While industry will continue to grow and substitute for agriculture, industrial growth has gradually decoupled from energy growth. Industry grew annually at the rate of 5.9 percent in the 1990s and at the rate of 7 percent between 2000 and 2005, while energy consumption in industry grew by only about 3 percent per annum over this period. The energy intensity of industry, thus, reduced from 46.2 PJ/$ Billion to 28.5 PJ/$Billion between 1990 and 2005. Some of these achievements and future policies are highlighted below.

Five Major industries (Iron and Steel, Cement, Ammonia, Aluminum and Pulp and Paper) account for 63 percent of total final energy use in industry in 2005[20]. While absolute energy use in these industries grew at 4.1 percent per annum between 1990 and 2005, the specific energy consumption in all the five industries reduced significantly (Table 1) Most notable is the iron and steel sector, which while accounting for over 30 percent of final energy use within industry in 2005, has reduced its specific energy consumption from 42 to 30 GJ/Ton (a decrease of 2.4 percent pa) over 1990-05. Similar conclusions have been reached by another study.[21]

India's cement industry – the second largest in the world after China – is also relatively efficient. The industry's average electricity intensity of 88 kWh/ton is the lowest in the world, compared to 119 in China and 140 in the US.

	Specific Energy Consumption in GJ / ton				
Type of Industry	**1990**	**1995**	**2000**	**2005**	**AAGR (1990-2005)**
Iron and Steel	41.9	37.6	33.3	29.1	-2.41%
Cement	3.6	3.4	3.3	3.1	-1.10%
Ammonia	55.3	60.4	51.9	42.9	-1.67%
Aluminium	399.0	393.8	380.5	364.9	-0.59%
Pulp and Paper	35.0	31.3	27.6	24.0	-2.48%

Source: Lawrence Berkeley National Laboratory, 2009

Table 1: Industry Energy Intensity Achievements

18 World Development Indicators, 2007.

19 The Government of India includes manufacturing, mining, construction, electricity and water supply in 'industry'. The LBNL report uses the same definition as the GoI, but some analysts include electricity and water supply under services, and not industry.

20 The share of these industries is 30%, 10%, 11%, 8%, and 5% for Iron & Steel, Cement, Ammonia, Aluminum, and Pulp and Paper respectively.

21 Binay Kumar Ray et al. 2007. Decomposition of Energy Consumption and Energy Intensity in Indian Manufacturing Industries, WP-2007-020, IGIDR.

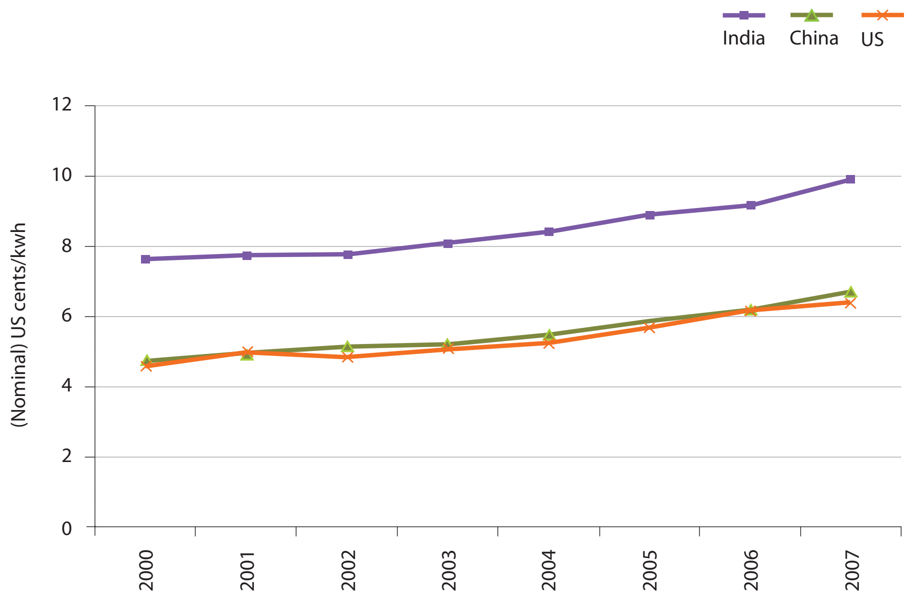
Future emphasis needs to be placed on broadening these achievements across industries. As noted in a recent study by the Lawrence Berkeley National Laboratory, "opportunities to reduce energy intensity still exist. While selected modern Indian units often display very high efficiency that approaches world best practice levels, the average intensity lags world best levels." [22]

Drivers

Energy efficiency improvements in industry have been driven by a number of factors, such as fuel price reform, competitive pressures from market liberalization, and, more recently, energy efficiency standards and regulations. Some of them are discussed below.[23]

High Energy Prices

India has one of the highest industrial electricity rates in the world, exceeding those in the US (Figure 6), in most developing countries and in the Organization for Economic Co-operation and Development (OECD), both in absolute terms and much more so on a PPP basis.[24] This is largely to finance subsidies to low income households and agriculture. Electricity-intensive industries have responded by generating electricity themselves, but have also been forced to economize on electricity use, since all fuel prices have increased since the nineties.



Notes: In PPP terms, these rates in 2007 in India were twice as high as those in China and four times as high as in the US.
China rates are average retail rates; industrial rates are close to but lower than these.
Industrial rates for India, for the year 2003 and 2004 have been interpolated.

Sources: US Energy Information Administration, Indian Planning Commission, Power Finance Corporation[25] Chun Chun Ni, 'A Primer for China's Energy Industry', Lawrence Berkeley National Laboratory, 2009 (forthcoming)

Figure 6: Industrial Electricity Rates: India, China and the US

22 Stephane de la Rue du et al.2009. India Energy Outlook: End Use Demand in India to 2020, Lawrence Berkeley National Laboratory.

23 The relative contribution of these drivers varies by industry. A full decomposition of energy growth is beyond the scope of this report.

24 Nagayama H. 2007. Effects of regulatory reforms in the electricity supply industry on electricity prices in developing countries. *Energy Policy*.

25 Power Finance Corporation, Report on the Performance of The State Power Utilities for the Years 2004-05 to 2006-07.

The steady liberalization of the Indian economy in the nineties included fundamental, albeit gradual, shifts in the energy industry towards market-based pricing. After decades of administrative pricing by the government, in 2002 companies were permitted to periodically adjust retail petroleum-based product prices based on an index tied to a basket of international fuel prices. Coal prices were partially deregulated by 2000. Prices have increased substantially since then, at an average rate of about 5 percent per year between 2001 and 2006. Recently, the Ministry of Petroleum and Natural Gas has also mooted the complete deregulation of crude oil prices.

Energy Efficiency Policies

The Indian government recognized the importance of energy efficiency in passing the Energy Conservation Act of 2001. The implementation of energy efficiency programs, however, has accelerated in the last few years through the efforts of the BEE under the Ministry of Power (MOP).

The MOP launched the Standards and Labeling program and the Energy Conservation Building Code (ECBC) in 2006 and 2007 respectively. Under these regulations, the BEE has launched several successful programs, and in the process made noteworthy progress in building an institutional infrastructure to regulate efficiency. Some of these achievements include:

- The manufacturers of four key electrical products (refrigerators, air conditioners, distribution transformers and fluorescent tube lights) have adopted labeling for their models. The BEE will make labeling mandatory from January 2010.
- 715 large companies are classified as 'Designated Consumers' and are required to appoint energy managers. The BEE will soon set efficiency improvement targets for each of these units.
- The BEE conducts National Certification exams, to train Energy Managers and Energy Auditors.

Furthermore, the BEE has embarked on a number of country-wide schemes across industries, many of which are recent and therefore bode well for future reductions in energy intensity. These fall into the National Mission on Enhanced Energy Efficiency, and include standards and labeling, market-based incentives, public procurement regulations, technology programs and financing assistance. The Prime Minister's Council on Climate Change approved the NMEEE "in principle", and claimed the mission will help save about 5% of annual energy consumption and nearly 100 million tons of carbon dioxide every year by 2015.[26]

Draft National Mission on Enhanced Energy Efficiency

Tradable Efficiency Reductions: Require efficiency reductions from designated industrial facilities. Permit trading of reductions to encourage cost-effectiveness.

Labeling: Require mandatory labeling for equipment & appliances in the residential and commercial sectors.

Public procurement: Amend procurement rules to explicitly mandate procurement of energy efficient products for all public entities.

Technology program: Replace inefficient appliances with efficient products such as efficient lighting, ballasts, AC, refrigerators in domestic sector.

26 http://pmindia.nic.in/prelease/pcontent.asp?id=998

Energy Conservation Building Code (ECBC): Mandate maximum energy consumption norms (per square feet) for new commercial buildings and existing buildings (through retrofit).

Energy Service Company (ESCos) Promotion: Support ESCo quality assurance through accreditation. Introduce capacity building through bankable efficiency retrofit demonstration projects covering all sectors countrywide.

Capacity building and information: Create a pool of trained manpower in states, government agencies, banks and financial institutions. Continue training Energy Auditors and Energy Managers.

Fiscal instruments: Allow tax exemptions for profits from energy efficiency projects by ESCos and Venture Capital funds. Reduce Value Added Tax (VAT) for energy efficient equipment (e.g. Compact Fluorescents)

Partial Risk Guarantee Fund: Provide commercial banks with partial coverage of risk exposure against loans made for energy efficiency projects.

Demand-Side Management (DSM) Programs in States

DSM has begun to take hold in India as a means of disciplining industrial and residential electricity demand growth. In several states (such as Delhi and Maharashtra), regulators have directed state utilities to undertake DSM programs and take advantage of their customer bases. Some of these initiatives include:

- Direct utilities to allocate budgets, generate plans and undertake load research
- Allow pass through of DSM program costs into rate base
- Introduce Time-of-Use rates
- Initiate capacity building on DSM within commissions and within utilities
- Initiate pilot/demonstration projects for energy efficient street lights, water pumping systems, traffic signals, and transformers

Through DSM and other state-promoted programs, as well as high consumer awareness the sale of energy saving Compact Fluorescent Lamps (CFLs) in India has already increased at an average of 40 percent per year, reaching over 200 million per year today. As a result, more than two third of active light points presently use fluorescent tubes or lamps.

Future Outlook

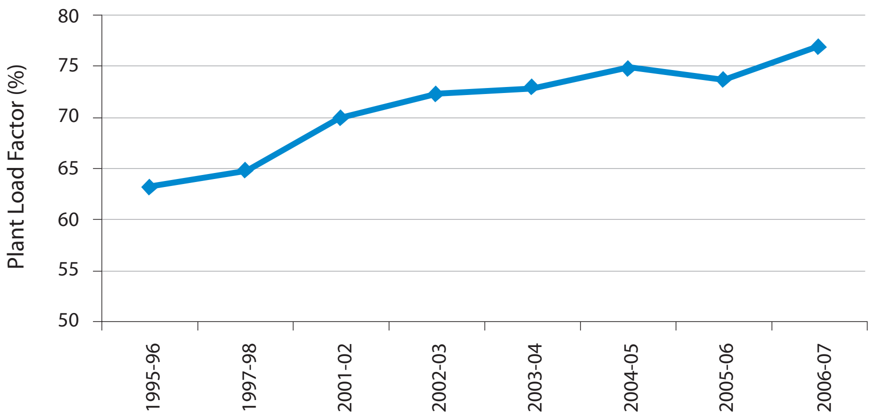
The efficiency achievements in Indian industry in the recent past are impressive, but sporadic. Significant opportunity exists to scale these up across the country. Indian industries, for instance, tend to have firms that exhibit a wide range of performance, including some firms that equal or exceed world standards, but a majority that lag behind best practices. In the electricity sector, a few utilities in states such as Maharashtra and Delhi have the institutional capacity and desire to implement DSM, but most others lack adequate knowledge or capacity.

At a national scale, the institutional infrastructure for promoting, enforcing and monitoring energy efficiency measures in India is nascent. Significant barriers to technology adoption exist, such as maintenance infrastructure for new technologies, information barriers, and government's enforcement capacity. The BEE's aggressive initiatives in the last few years appear to set in place this much-needed infrastructure, albeit slowly.

India's industry has a sizable small-scale enterprise sector (constitutes 33 percent of value added to industrial GDP, 2004), which employs over 3 times the number of people employed in the organized industrial sector.[27] A significant improvement in energy efficiency is possible in these units. However, this sector is difficult to understand and to influence. A large component of trade in these industries takes place in an informal cash economy, where policy has limited reach.

B) Electricity Sector

The power sector faces many challenges – large power shortages, inadequate access coverage, and financially crippled electricity companies. As a result, reform efforts in recent decades have accorded higher priority to these challenges than to improving efficiency.



Source: Central Electricity Authority, India

Figure 7: Power Plant Utilization Improvements

Power Generation

India's electricity generation is dominated by inefficient coal – which constitutes about 53 percent of the generation capacity. However, several measures are being taken to increase the efficiency of these coal plants.

Several Renovation and Modernization (R&M) and life extension programs have led to the overall improvement of the Plant load factor (PLF) of Thermal Power plants. The PLF of thermal plants has increased from 63 percent in 1995-96 to 77 percent in 2006-07[28] (Figure 7). This has been accompanied by a fall in the auxiliary consumption of coal plants from 9.4 percent to 8.37 percent over the similar period. Further improvement is expected in the 11th Plan, wherein 11 GW of plants (about 15 percent of installed coal capacity) and another 18 GW (about 25 percent of installed coal capacity) are targeted for life extension and 'Renovation and Modernization' respectively[29].

27 Micro and Small Enterprises employed about 30 million people in 2005-06 according to the Economic Survey of India.

28 Central Electricity Authority, CEA, Performance Review of Thermal Power Plants, 2007-08.

29 CEA (http://www.cea.nic.in/thermal/Renovation%20&%20Modernization/8.htm)

Distribution Losses

India is known to have some of the highest Transmission and Distribution (T&D) losses in the world. These losses are both physical (weak, overloaded networks) and commercial (power theft). Several policy and regulatory efforts aim to improve services to the poor and reduce financial losses. Regulatory commissions have annual targets for reduction in T&D losses. But progress has been limited. Average T&D losses have only reduced from 34 percent to 30.4 percent between 2002 and 2006.

There are notable exceptions, such as the states of Delhi, Gujarat, and Andhra Pradesh where losses have dramatically reduced in the last decade. In future, states will be able to push loss reduction by taking advantage of several programs launched by the Government of India (GoI) to subsidize electric grid expansion and upgradation to the extent of about US $2 billion per year.[30]

Agricultural Consumption

Agricultural policy has been a long-standing drain on the electricity sector. Groundwater is the main source of irrigation for agriculture in India. Agricultural pumping consumes a fifth of electricity use in India. Political decisions made in individual states in the 1970s to provide subsidized electricity, and in the 1980s and 1990s to provide virtually free electricity, for irrigation have had long-term negative impacts on the electricity sector as a whole, notwithstanding recent reform efforts to scale back these subsidies. Since meters were removed during this period, agricultural rates in India for majority of agricultural consumers are based on the pump size, not metered consumption. This has created several inefficiencies in the entire system – pumps are inefficient, price signals for crop selection are limited, water tables are falling rapidly, and poor farmers who do not have access to irrigation face water scarcity. The effective subsidy, though partially compensated by the government, contributes to the financial plight of the electricity companies. Paradoxically, ground-water continues to be the back-bone of Indian agriculture, although extraction has now reached unsustainable levels as a result of these policies.

Numerous reforms have been attempted to address these problems. Several states have begun to build separate lines for agriculture to enable utilities to control electricity supply to farmers without affecting households. For example, one successful program in the state of Gujarat, called the *Jyoti Gram Scheme*, has reduced tubewells' electricity use by 37 percent from 2001 to 2006. This halved the farm power subsidy from US$788 million to US$388 million. In addition, rural households benefited from uninterrupted supply.[31] Other efforts include groundwater recharge and load rationing.

C) Transportation

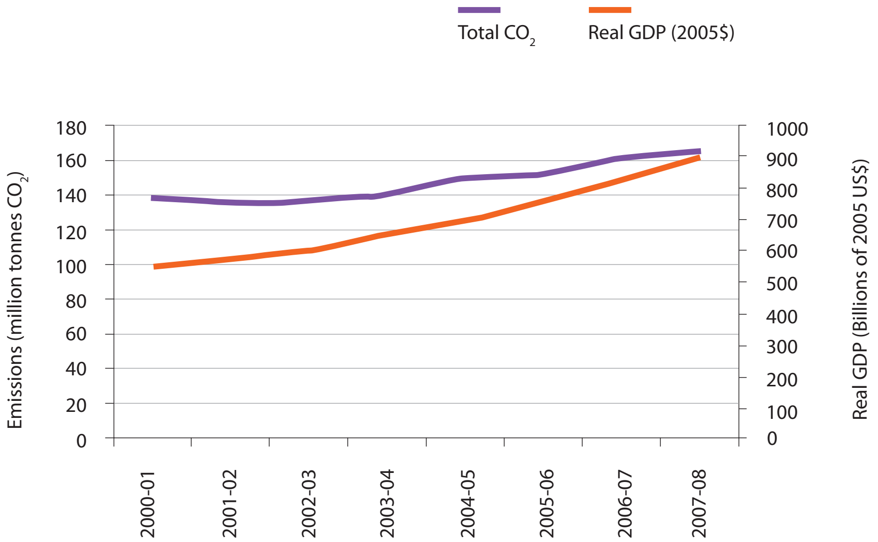
In contrast to the global average, where transportation makes up about a quarter of total energy demand, the transportation sector in India is responsible for about 15 percent of total commercial energy consumption[32]. The overall carbon impacts from transportation are growing at a slower rate than real GDP (Figure 8).

---

30 The Accelerated Power Development and Reform Program (APDRP) and Rajiv Gandhi Gramin Viduytikarn Yojana (RGGVY) are the prominent ones. APDRP facilitates IT and other capital investments to reduce T&D loss using performance-based grants. The RGGVY offers a 90 percent subsidy for strengthening rural electricity networks, with the aim of achieving 100 percent household electrification.

31 Shah, T. et al., Groundwater governance through electricity supply management: Assessing an innovative intervention in Gujarat, western India, Agricultural Water Management. (2008).

32 International Energy Agency (2007). World Energy Outlook 2007: China and India Insights. OECD, Paris.



Source: Ministry of Petroleum and Natural Gas, India 2009; Economic Research Service, US Department of Agriculture, 2009

Figure 8: Transportation CO_2 Emissions and GDP Growth

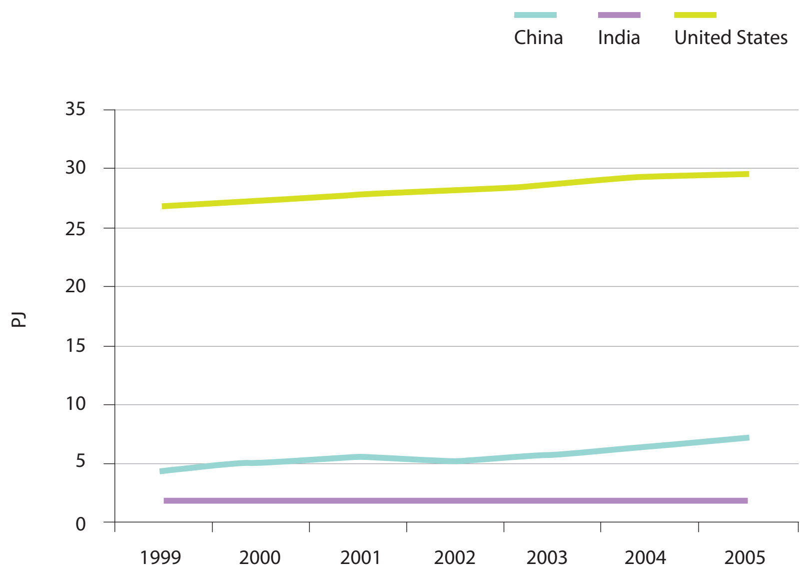
Freight and passenger transportation account for roughly equal amounts of energy, but diesel makes up more than 70 percent of petroleum demand in the sector, mainly because of its use in trucks and buses and a significant fraction of the light-duty vehicle (LDV) fleet. The main drivers of energy demand in the transportation sector are road freight and personal transportation. Despite substantial demand growth in both these categories, the growth in fuel demand has been comparatively low in part because high fuel prices have disciplined fuel demand growth in each segment. In the period 2000-2005, demand In India for petrol and diesel grew at a much slower pace than they did in other major economies, especially China and the United States (Figure 9). Total Indian consumption in 2005 was less than the incremental consumption of China or the US during the period 1999 to 2005.

India's freight intensity, i.e., tonne-kilometres per $ of GDP, has historically been high relative to many other countries, including the United States, because of a combination of factors, including the relatively large role played by manufacturing in the economy (Figure 10).[33] The rapid increase in the share of road freight (which is costlier than rail transportation) combined with the rise in the share of service sector in GDP has, however, caused a decline in this indicator. Although it was still 40 percent higher than in the United States in 2004, it is likely to keep falling.

India's freight energy intensity, measured as the energy required for a tonne-kilometre of freight, compares well with China and the USA, which are in the range of 1.2 to 1.4 MJ/Ton-km, and is substantially lower than Europe (2.5 MJ/ Ton-km).[34]

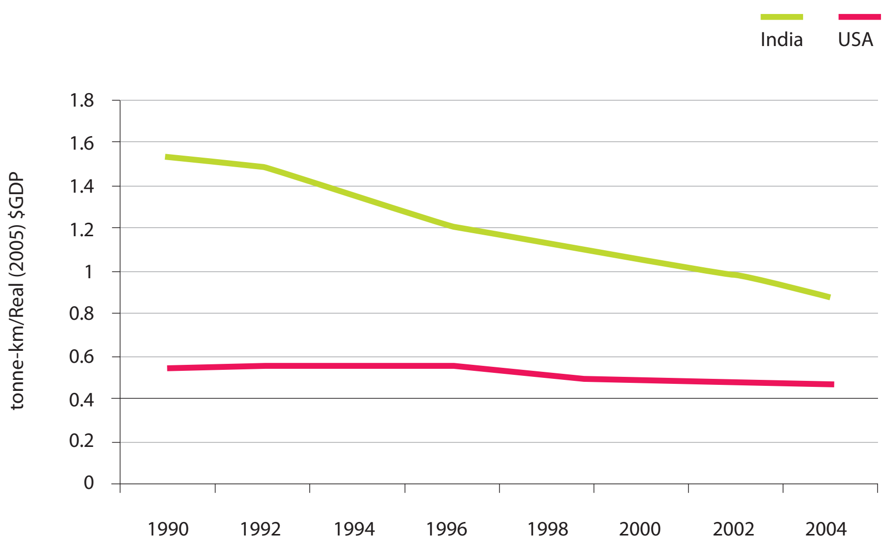
33 If non-motorized freight modes (such as handcarts, bullock-carts, tricycles, and so on) were included, this indicator would perhaps be even higher.

34 IEA/SMP Transport Model, 2005.



Source: Energy Information Administration
Note: Includes gasoline and distillate fuel oil.

Figure 9: Road Transportation Fuel Demand: India, China, and the US



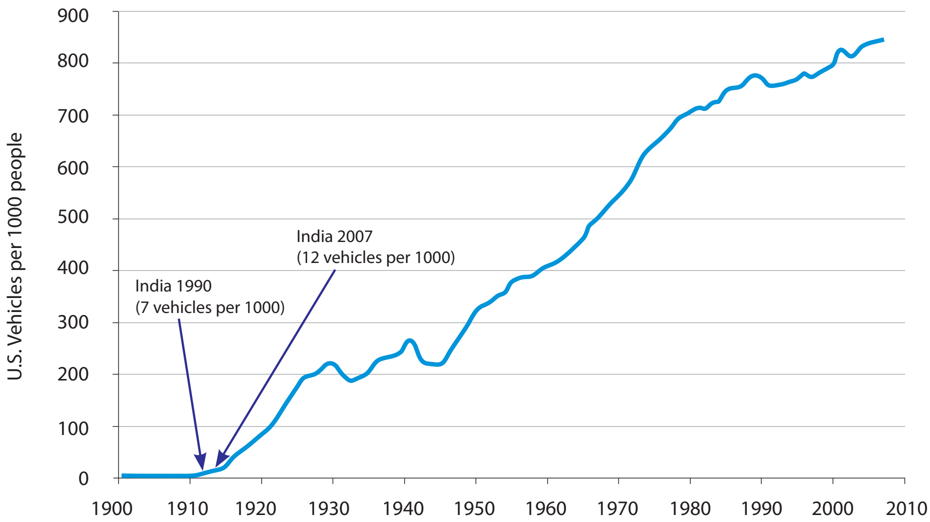
Source: De la Rue du Can et al., 2009, Oak Ridge National Laboratory (http://cta.ornl.gov), Economic Research Service, US Department of Agriculture, 2009.

Figure 10: Freight Intensity: India and the US

Drivers

The low energy use per unit passenger-km in India is driven by four key factors:

First, non-motorized modes of transport, walking and bicycling, are known to meet more than a quarter of all trips in major cities and greater than half in small towns and rural areas. Second, public transportation, primarily buses followed by rail, satisfy more than three-quarters of passenger demand for motorized transportation. Third, despite high growth, India has low ownership of vehicles. LDVs - cars and SUVs - together account for just about one-fifth of motorized passenger demand (in contrast with 90 percent in the US). Even though the total vehicle stock in India increased from 19 million in 1990 to 68 million in 2004, India had about 12 LDVs per 1000 people in 2007, in contrast to over 800 LDVs in the US (Figure 11). Fourth, small vehicles, usually two-wheelers with low power, dominate motorized transport. Two-wheelers make up over 80 percent of the current vehicle stock but consume around 15 percent of road-transportation fuels.



Source: Oak Ridge National Laboratory, US (http://cta.ornl.gov/).

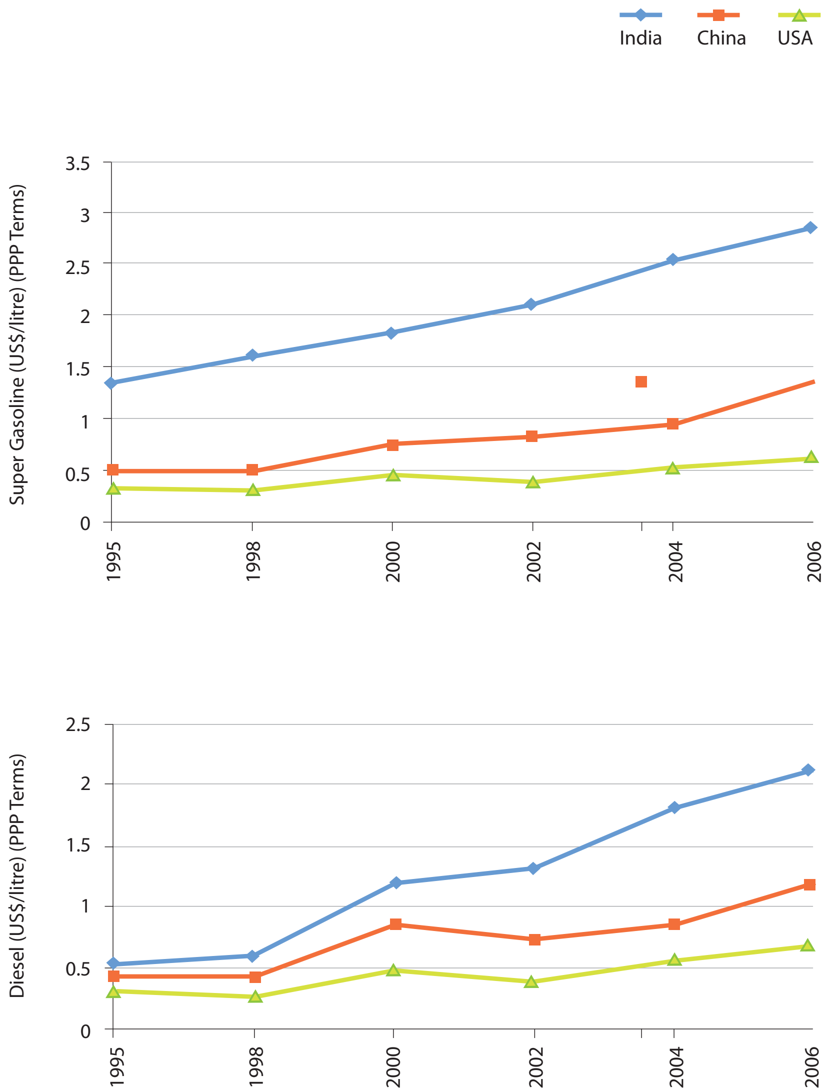
Figure 11: Growth in Light Duty Vehicle Ownership Rates in the US and India

High Energy Prices

Retail prices of petrol (gasoline) in PPP terms have been about more than four times those of the US and almost double of those in China. Diesel prices in PPP terms were about three times those of the US and almost double those of China in 2006. Diesel prices have been on the rise since the government phased out the Administered Price Mechanism (APM), which subsidized diesel (Figure 12). Even in market exchange terms[35], the Super Gasoline prices in India in the year 2006 were about 1.5 times higher than the US and China prices. Diesel prices in market exchange terms in 2006 in India were 6 cents higher than in the US and about 14 cents higher than in China.

35 PPP-adjusted prices are more appropriate measures for comparison, since they measure relative affordability.

In addition, fuel demand growth has been disciplined by other factors as well: (a) the improved efficiency of new cars, trucks and two-wheelers, (b) higher international oil prices, (c) increased vehicle load factors, (d) some revival in rail for freight transportation, and (e) fuel switching in public transportation in some major cities from diesel towards compressed natural gas (CNG).



Source: GTZ (www.gtz.de), International Fuel Prices 2007

Figure 12: Retail Gasoline and Diesel Prices - India, China and the US

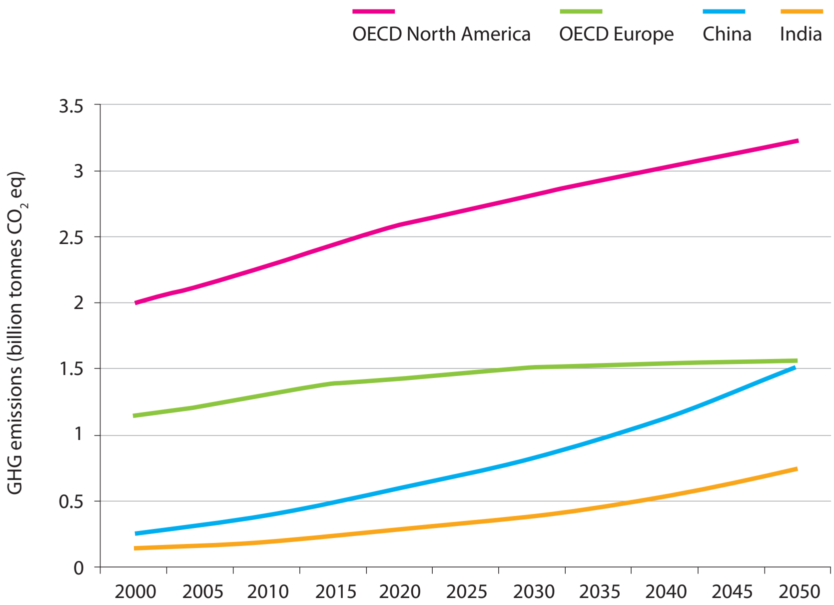
Transportation Policies

Several proposed policies can positively influence the carbon intensity of transport in India. The government has a policy to increase biofuel use in the transportation sector to 20 per cent ethanol-blended petrol and diesel across the country by 2017. The 11th Five-year plan (2007-2012) endorses policies for improving the efficiency of new vehicles and advocates inter-modalism and better integration of urban land-use with transportation. In freight, Dedicated Freight Corridors are planned to double stack container trains to reduce the unit cost and improve throughput.

The National Urban Transport Policy (NUTP) of 2006 places emphasis on integrated land-use and transportation planning to minimize travel and improve access, especially for the poor. The policy is especially progressive in that it seeks to improve the allocation of road space for people, rather than vehicles, as its focus and calls for reserving lanes and corridors exclusively for public transportation and non-motorized modes of travel. Similarly, it emphasizes safety concerns of cyclists and pedestrians and the construction of segregated rights of way for bicycles and pedestrians. It is not clear, however, whether the policy can play a substantial role in actually prioritizing such actions over infrastructure development for private transportation at the local level, given the framework of budgetary allocations and governance in the transportation sector.

Future Outlook

Based on Reference forecasts of the International Energy Agency's Sustainable Mobility Project (SMP) Transport Model, India's CO_2 emissions from transportation are expected to grow at an annual rate of about 3.5 percent until 2050, which is only slightly lower than China's anticipated growth rate. Its total emissions will still be only about half of China's and OECD Europe and about a quarter of OECD North America (Figure 13). In per capita terms, even with no new policies, India's per capita emissions from transportation in 2050 will still be about one-twelfth of that in OECD North America and half of that in China. The recent transportation policies related to fuel economy and clean fuels, if implemented as planned, are likely to reduce overall carbon emissions relative to the reference projections shown.



Source: IEA Sustainable Mobility Project (SMP) Transport Model 2005, Reference Case

Figure 13: Transportation Sector CO_2 Emissions Trend: India, China, US, Europe

Urban Development Challenges

India's cities and towns have high levels of density and mixed land-use in comparison with many urban regions elsewhere. This tends to reduce passenger commuting distances, but creates serious problems of congestion, noise, pollution, traffic fatalities and injuries, and inequity in access. For example, India's fatality rate on roads of about 270 deaths per 100,000 vehicles, when measured against total registered vehicles, is among the worst in the world,[36] This is in large part because of poor road planning, improper facilities in many urban areas for non-motorized modes and pedestrians, and inadequate funding for public transportation.

Under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), some 64 cities and towns have been identified for substantial new funding for improved infrastructure, including non-motorized modes, pedestrian access and public transportation. It remains to be seen whether these actions will indeed improve access, reduce local and GHG emissions and, most significantly, reduce fatalities.

D) Residential Energy Use

The residential sector comprises about 39 percent of final energy consumption in India, but only 19 percent of final commercial energy consumption, because biomass dominates household energy use in rural areas.

While emissions typically rise with income in a given society, countries differ widely in how energy intensity trends with income. Household energy consumption characteristics mirror the state of development, infrastructure, and social and cultural norms of a society. Indeed, a study of household energy intensity in developing and developed countries found that households with similar expenditure levels across countries, adjusted for differences in standards of living, had energy intensities that varied by over a factor of three.[37] In particular, households in India had about half the energy intensity of households with similar income in Brazil, and a third of that of comparable American households.

Part of the reason for this is that certain aspects of Indian lifestyle and patterns of urban development lend themselves to low energy use. Two such characteristics are vegetarianism, and dense urban development. The former serves to reduce the energy intensity of food consumption, while the latter affects the energy needed to build and cool homes, and commute to work.

Meat Consumption

Indians consume nearly 1/11th of the meat eaten by an average Chinese and 1/25th of that eaten by an American.[38] Despite growing meat consumption, therefore, India's aggregate meat consumption is a mere fraction of both countries' consumption (Figure 14).

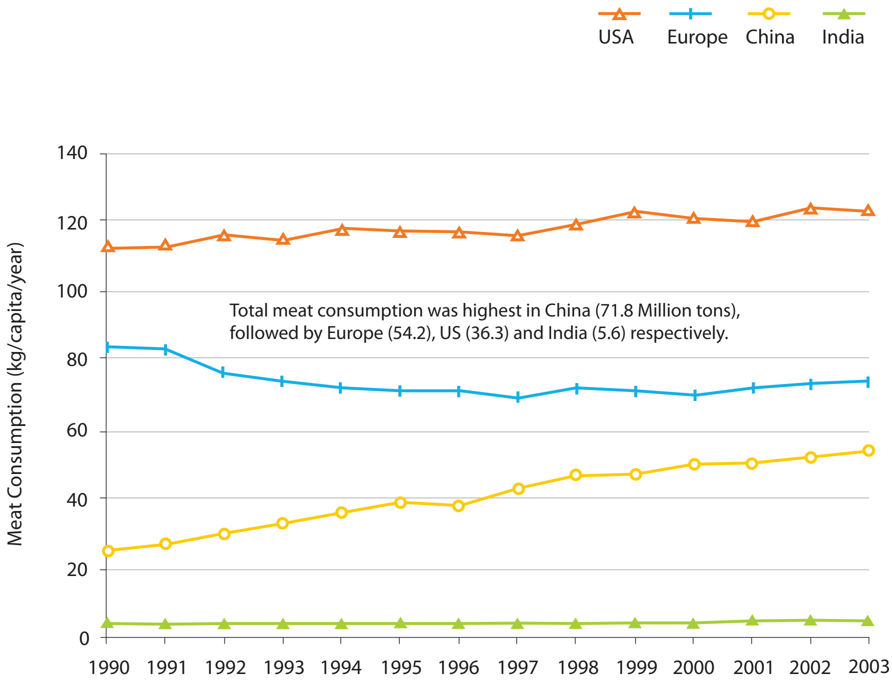
The carbon impacts of the meat industry are known to be significant, not just from its high energy intensity, but even more so from its land use impacts. The FAO estimates that direct and indirect emissions (including land use change) from the livestock sector contribute 18 percent of global GHG emissions. This is in addition to numerous other health and environmental impacts caused by livestock production.[39] Stehfest et al have explored the potential impact of dietary changes on achieving ambitious climate stabilization levels. They found that "a global food transition to less meat, or even a complete switch to plant-based protein food to have a dramatic effect on land use. Up to 2,700 Mha of pasture and 100 Mha of cropland could be abandoned, resulting in a large carbon uptake from regrowing

36 World Health Organization 2009. Global Status Report on Road Safety: Time for Action. Geneva.

37 Lenzen et al 2006.

38 Food and Agricultural Organization (http://faostat.fao.org/site/569/default.aspx#ancor)

39 Livestock production consumes eight percent of the world's water (mainly to irrigate animal feed); causes 55 percent of land erosion and sediment; uses 37 percent of all pesticides. *Livestock's Long Shadow,* Food and Agricultural Organization, 2006, Stehfest et al, 2009. Climate benefits of changing diet. *Climatic Change.*



Source: FAO, (http://faostat.fao.org/site/569/default.aspx#ancor)

Figure 14: Meat Consumption Patterns - India, China, Europe and the US

vegetation. Additionally, methane and nitrous oxide emission would be reduced substantially. A global transition to a low meat-diet as recommended for health reasons would reduce the mitigation costs to achieve a 450 ppm CO_2-eq. stabilization target by about 50% in 2050 compared to the reference case."[40]

Urban Density

Indian cities have some of the highest urban population densities in the world. Almost a third of India's population lives in cities. About 30 percent of India's population lives in homes of less than 540 square feet.[41] Growing urban density forces even wealthy families to live in small spaces, and in apartment buildings instead of independent houses. Smaller homes generally need less energy to build and to cool. People living in cities also commute less than those living in suburbs. Thus, people living in metropolitan areas in India would tend to have lower carbon footprints than those in other countries with greater urban sprawl.

City infrastructure, however, cannot keep up with this growth. Slums now comprise one-quarter of India's urban housing, matching the share of the urban poor.[42] These slums often have limited access to water, sanitation and energy services. We did not review literature on the energy impact of alternative urban development patterns. But it is reasonable to expect that the provision of secure and reliable housing and services will significantly increase energy use.

40 Stehfest et al, 2009.

41 National Sample Survey Organization, Ministry of Statistics and Program Implementation, India, 2008.

42 World Bank, India. (http://go.worldbank.org/C6H9E76S60)

Cooking Fuels

Seventy four percent of rural India and 21 percent of urban India continues to rely on biomass-based fuels for cooking. Cooking energy comprises 90 percent[43] of rural India's total energy requirement. This has mixed consequences for climate. Carbon dioxide emissions are low, since a large part of these fuels are byproducts of cattle or agricultural waste. However, the combustion of these fuels produces black carbon, which has recently gained significantly publicity for its short-term impact on global warming.[44]

However, as mentioned earlier, the provision of modern fuels to Indian households has a modest carbon impact, and significantly reduces indoor air pollution. Providing this 74 percent of rural households with gas for cooking would require 0.1 tons of CO_2 per capita, or a total of less than 70 million tons. This is less than 1 percent of US CO_2 emissions. Alternatively, given the uncertainty in availability of sufficient quantities of gas to meet this demand, providing poor households with efficient, clean cookstoves could reduce indoor air pollution while continuing to emit low or no carbon emissions.

Efforts are being made by the government to switch to more energy efficient cooking fuels like liquid petroleum gas (LPG). The Ministry of Petroleum and Natural Gas (MoPNG) recently announced as a part of its 'Vision 2015' its intention to provide 55 million new LPG connections to raise the population coverage from 50 percent to 75 percent. Most of these new connections would be released in rural areas as urban areas are largely covered[45].

Electricity Use

Electricity is the most elastic household fuel with respect to income, but is less elastic with respect to price. Nevertheless, India's progressive electricity pricing and efficiency programs may mitigate growth in household electricity use.

	Population Share (%)	**Electricity Demand Share (%)**
Electrified Household Population	Top 20	53
	Middle 40	34
	Bottom 40	13

Source: National Sample Survey Data, 2004-05

Table 2: Distribution of Electricity Consumption by Income Class

Electricity powers most of the appliances that come with increasing wealth. It is no surprise that over half of electricity consumed in India in 2004-05 serves the top 20 percent of the population (Table 2). It can be expected, as a natural consequence of development that per capita electricity consumption will increase with poverty alleviation. As discussed earlier, if the government initiatives on energy efficiency are implemented successfully, this growth has the

43 De la Rue du Can et al, 2009. Residential and Transportation Energy Use in India: Past Trend and Future Outlook, Lawrence Berkeley National Laboratory.

44 V. Ramanathan, et al, 2005; and http://www.yaleclimatemediaforum.org/2009/07/black-carbon-and-global-warming/

45 Ministry of Petroleum and Natural Gas.

potential to reduce overall electricity intensity of household electricity use. In addition, the block pricing structure, where higher quantities of consumption are charged higher rates, also disciplines electricity use to an extent. For example, in several cities, consumption above 300 kWh per month (which is only a third of average US household consumption) is charged US 20 Cents /kWh (50 cents/kWh in PPP terms). In comparison, the average residential rates in the US are about 10 cents/kWh. In Europe, average residential rates range from US 12-45 cents/kWh.[46]

Summary

In summary, the low and decreasing energy intensity of the Indian economy is driven by the following factors:

(a) fundamental structural aspects of the economy – such as vegetarianism, high use of public transportation, high urban density;

(b) changes in the composition of economic activity from agriculture, predominantly towards services, and low energy intensity industries; and

(c) steady improvement in energy efficiency within several sectors – which are in turn driven by high, progressive energy prices, and, more recently, systematic policy efforts towards regulating energy efficiency.

The continued decline in energy intensity will depend on the future structure of the economy, and the success of policy initiatives to encourage energy efficiency. A stable or growing share of services relative to manufacturing, successful implementation of energy efficiency programs more widely across industry and households, improvements in electric supply and delivery efficiency, increased public transportation systems and high efficiency vehicle penetration will all serve to reduce energy intensity further.

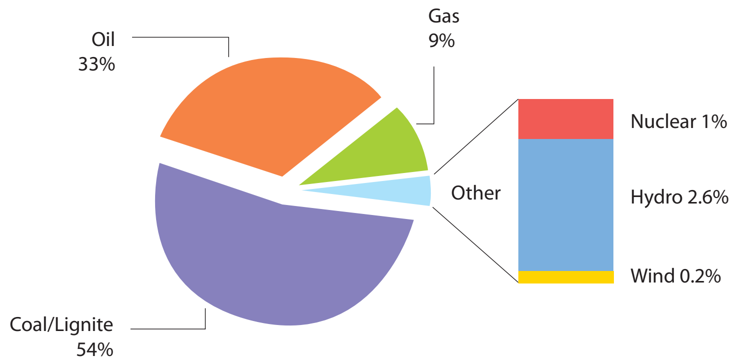
In addition, greater attention by policy makers to provide secure housing and basic services to the poor using energy-efficient and material-conserving technologies would greatly reduce the likely carbon impact of future growth.

46 Assuming a nominal exchange rate of $1.4 per Euro. www.energy.eu/#prices

III Carbon Intensity

This section focuses on the carbon content of energy use, which is largely about the fuel mix of energy production.

Coal dominates fuel use in industrial production directly, and indirectly through industrial electricity use (Figure 15). Oil products comprise the second largest share with 33 percent, of which about half are used in transportation and less than a quarter by industry.[47]



Source: Indian Planning Commission (http://planningcommission.nic.in/sectors/energy.html)[48]

Figure 15: Fuel Mix of Energy Production

Despite coal's dominance, India's overall carbon intensity of energy use has marginally decreased in recent years (Figure 16).[49] Some of the factors that are responsible for this decrease include a strong penetration of wind capacity, and efficiency improvements in coal-based electricity production.

A) Renewables

While coal is and will likely continue to remain the dominant fuel source, India has historically promoted the development of all fuels in order to bridge a chronic supply shortage. Since 2000, capacity additions from renewables (excluding large hydro) comprise nearly a quarter of total additions in the Indian power sector, and almost half with large hydro. In comparison, coal additions comprise just 37 percent (Figure 17). Wind capacity has grown at an average annual rate of 26.6 percent between 2000 and 2008, reaching 10 GW in 2008.[50]

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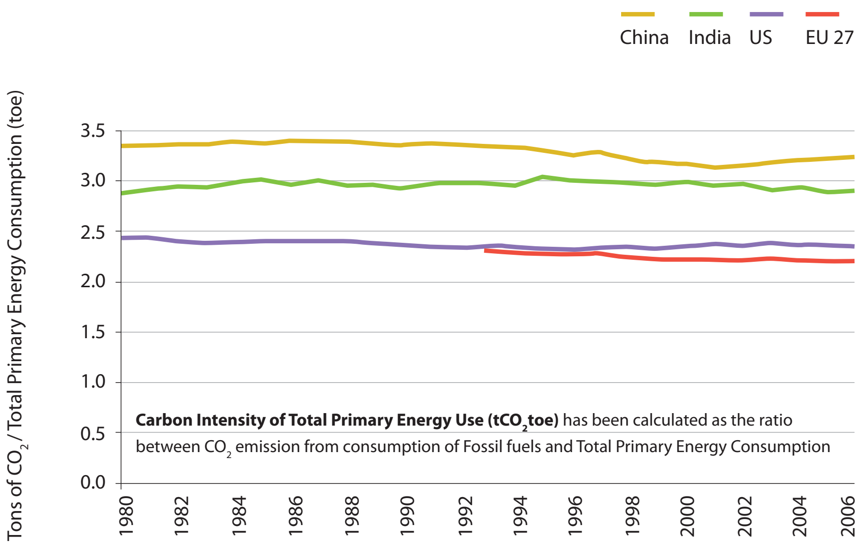
47 Petroleum Conservation Research Association, PCRA is an accredited Energy Auditing Agency in terms of EC Act 2001(http://www.pcra.org/)

48 Commercial Energy does not include Biomass.

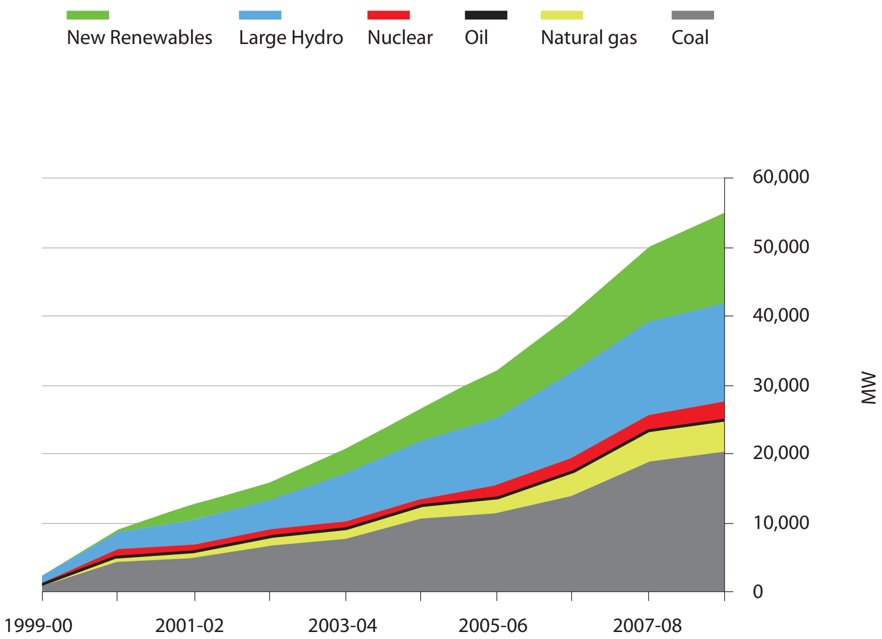
49 WRI data shows much lower carbon intensity for India, compared to the EIA data.

50 Global Wind Energy Council (www.gwec.net), 2007 and MNRE, India.



Source: Energy Information Administration, US Department of Energy

Figure 16: CO_2 Intensity of Energy Use – India, China, US, and the EU



Coal based capacity comprised 37% of the total capacity additions in the last decade, while renewables, including large hydro, contributed 50%.

Source: Ministry of New and Renewable Energy, Central Electricity Authority

Figure 17: Incremental Electric Capacity Additions by fuel

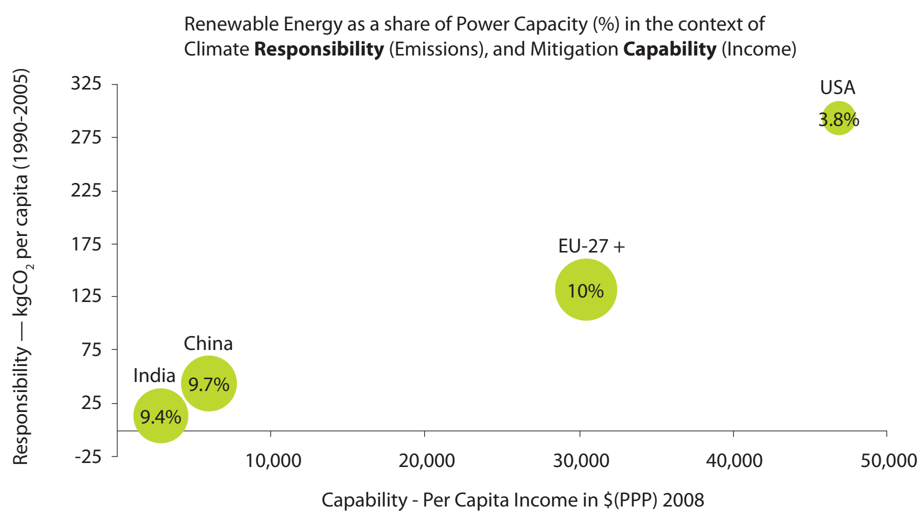
As a result, among the countries with large installed capacities, India has one of the highest shares of renewable sources of electricity in the world, equal to that of China and EU. The share of non-hydro renewables is currently 9.4 percent. With large hydro, which accounts for a third of India's power capacity, India has the highest share of renewables compared to the US, China and the EU (Table 3).[51]

	India	USA*	EU 27 + **	China
Modern Renewables (MW)	13,879 (9.4%)	41,877 (3.8%)	90,831 (10%)	75,910 (9.7%)
Renewables & Large Hydro (MW)	50,526 (34%)	119,521 (11%)	291,689 (32%)	187,430 (24%)
Total Installed Capacity (MW)	148,039	1,096,992	907,866	785,000

** Total Installed Base Data for USA is for 2007*
*** EU-27 +: Includes Croatia, FYROM, Iceland, Norway, Switzerland & Turkey*

Table 3: Renewable Electricity Penetration (2008)

The high level of penetration in India and China compares favorably with that of the EU and far exceeds that of the US. This is noteworthy, given that, from a climate perspective, the EU and US have a greater responsibility (high cumulative and per capita emissions) as well as higher capacity (high per-capita income) to afford the higher cost of renewables (Figure 18).



Bubble size represents Modern Renewable Capacity (Excluding Large Hydro) as % of total installed capacity. Figures inside the bubble are actual values.

Note: In energy terms, renewables comprise 4.5-6.3 percent in India, China and EU+, and 3 percent in the US in 2008.*
** Latest available data for China is for 2006*

Figure 18: Renewable Energy Share: In the context of Capability and Responsibility

51 In energy terms, renewables comprise 4.5-6.3 percent in India, China* and EU+, and 3 percent in the US in 2008.
* Latest available data for China is for 2006

India's high renewables share has to be seen in the context of its substantial resource limitations. Over two thirds of modern renewables in India come from wind power. This is in spite of the fact that India has less favorable wind resources in comparison to USA, EU and China. Most wind sites in India classify as Class 3 or lower, while the other regions have abundant sites in higher Class categories. This makes Indian wind farms less productive and more expensive, holding all else equal. On-shore wind potential in India is less than that in UK and is 4 percent or 8 percent of the potential in US and China.[52] The availability of biomass is limited and competes with a sizable poor population.

Decentralized Renewable Energy Systems

Central and State government levels seem to be willing to fund decentralized electricity generation, but without robust technology and implementation mechanisms they are unable to scale their initiatives..

The Indian government promotes distributed, renewable energy systems through subsidies to photovoltaic (PV) home lighting systems (for remote areas), solar lanterns and solar cookers. Solar water heating systems have been made mandatory in new buildings in many municipal corporations across India. The Delhi government, for example, offers a subsidy of $175 per solar water heater from the state budget. The total cumulative installed collector area in India is presently 2.6 million sq m.[53]

Manufacturing Capacity

Several proposals for new manufacturing facilities, totaling almost 6,000 MW as of late 2008, if successful, could make India a leading global producer of PV. Indian solar PV manufacturing capacity presently stands at 335 MW of modules and 110 MW of cells. The government has encouraged semiconductor fabrication. The GoI's recent Special Incentive Package Scheme (SIPS) attracted a large number of proposals, of which the GoI has already cleared twelve for further evaluation, with an expected investment of USD 15 billion over 10 years.[54] The government plans to subsidize 20 to 25 percent of the capital costs of these projects.

Drivers of Renewable Electric Generation

Since the early nineties, the Indian government has actively promoted foreign investment in renewables. The GoI set up a ministry and an institutional infrastructure to assist in project development and financing. A second wave of investments was stimulated by the institution of independent regulators in states, many of whom have set up RPO, legally supported by the Electricity Act of 2003 (EA 2003) and the Electricity Policy 2005.

Renewable Purchase Obligations

Independent regulators in 17 states, which account for roughly 92 percent of the power consumed in the country, have RPO targets in place. Most states have targets for 2009-10 in the range of 8-10 percent, with some as high as 20 percent. Some regulators are expected to increase their targets at the end of the RPO period. Recently the Forum of Regulators, a statutory body representing all electricity regulators, published a report suggesting that (a) all state electricity regulators should specify a minimum RPO at 5 percent and offer a preferential feed-in rate till the end of the loan term of renewable projects, and (b) Renewable Energy Certificates be institutionalized to permit trading and overcome regional resource disparities.[55] The Central (Federal) Commission has published benchmark technical and

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52 Xi Lua et al, 2009.

53 Ministry for New and Renewable Energy (MNRE).

54 http://www.thehindubusinessline.com/2009/06/03/stories/2009060351681500.htm

55 Forum of Indian Regulators 2008. Policies on renewables: Report; November 2008.

financial parameters for different renewable generation technologies to enable state regulators to set feed-in rates for grid-connected projects.

Support by Central and State Governments

Financial incentives from state and central government have complemented regulatory efforts to promote renewables. The most important incentives from the Central Government include (1) accelerated depreciation of 80 percent in the first year, (2) 10 year income tax exemption, and (3) excise and customs duties exemptions. Some of these policies have even begun to make explicit reference to climate change as a policy imperative. For example, the recent bio-diesel and wind machine import duty exemptions was apparently motivated in part *"(to enhance) contribution of new and renewable energy sources of power… to successfully combat the phenomena of global warming"*.

Various state governments have given additional incentives, such as introducing market mechanisms to facilitate the sale of renewable energy over the electric grid, or raising funds to support renewables. For example, Maharashtra state introduced a levy on industrial and commercial electricity consumers, the revenues from which would be used to promote renewables in a variety of ways.

Future Outlook

The share of renewables in the installed mix is likely to sustain, if not grow, particularly given the regulatory incentives in place at both the national and state level. With a projected technical potential of over 65 GW,[56] grid-connected wind will likely continue to dominate renewable energy development in India.

The government targets in the current 5-year plan include capacity additions of 30 GW from renewables (including large hydro), or about 40 percent of additions. By 2020, the government expects to add another 30 GW from renewables excluding large hydro. Although historically actual additions tend to fall short of their targets, in the past decade India has overachieved in its targets for renewables additions.

Renewable Energy Law and Solar Initiative

The need and usefulness of a renewable law has been demonstrated in the success of renewables in Germany and China. To further empower the Ministry of New and Renewable Energy (MNRE) to increase the deployment of renewables, the Energy Coordination Committee chaired by the Honorable Prime Minister (on June 27, 2008) put forth a Renewable Energy (RE) Law for parliamentary approval. MNRE has been entrusted with the task of preparing the RE Law, which should be in place shortly.

National Solar Mission and Solar Power Policy of Gujarat

The GoI, under the National Action Plan for Climate Change (NAPCC), announced the Solar Mission, under which it plans to incentivize solar-powered generation through feed-in rates, 10 year tax exemptions, customs and excise duty exemptions, and solar-specific RPO (1-3 percent) by 2020. Utilities, state and central governments would share the cost of the subsidy. GoI has also mooted an idea of 'solar fund', which would be partly financed through a tax on Coal, Petrol and Diesel (much like a carbon tax). Through these initiatives, the GoI proposes to add 20 GW of electricity capacity from solar PV and solar thermal by 2020.

56 Global Wind Energy Council (www.gwec.net), 2007.

Gujarat has also announced a Solar Power Policy-2009, under which it plans to buy 500 MW of solar thermal and solar PV based power at a declining rate schedule.[57] Projects under this policy will all receive duty exemptions and tax benefits.

B) Coal Sector

India consumes nearly 75 percent of its coal for power generation. Under business-as-usual conditions, this share is likely to increase. India's future carbon intensity depends heavily on technology shifts in the coal sector towards super-critical coal plants.

Most coal power plants in India use sub-critical technology, which have low efficiencies. The net efficiency of India's coal plant fleet in 2003 was 29 percent compared to 33 percent in the US.[58] Today the best available technology (ultra-supercritical technology) has a net efficiency of 40 – 44 percent.[59]

The prospects for a shift towards super-critical seem promising. India expects to double its coal capacity in about a decade. Fifty to sixty percent of coal plants additions projected for the 12th Five-year plan are likely to be super-critical.[60] This share is expected to increase with the promotion of private sector consortia in the equipment supply market. (Currently, the government-owned company, the Bharat Heavy Electricals Ltd. (BHEL), is the only supplier). In addition, the Central Electricity Authority (CEA) is considering the retirement of 5 GW of old and inefficient small power plants.[61]

Coal mining in India also needs technology improvements, which will reduce the ash content of coal and improve power plant performance. This is underway in public sector mining companies. Mining leases have also been given to many private companies in the last few years – which are expected to be efficient.

C) Other Sources

In keeping with its goal of energy security, the Indian government actively promotes hydro, nuclear generation and domestic natural gas. Although highly controversial on several fronts – social, environmental and economic (for nuclear) - if implemented, all these sources will serve to reduce the carbon intensity of the Indian energy sector. The government has ambitious plans for all three fuel sectors. The natural gas targets seem politically most feasible, but the sector's success depends on the extent of commercially viable domestic gas production and the establishment of effective institutions for gas markets.

Hydro and Nuclear

Social and environmental externalities related to big dams are well-known. India does not follow the decision-making process recommended by the World Commission on Dams. The Indian government has perpetually faced criticism for its record on the rehabilitation of displaced people and on dam performance. Nevertheless, the government aims to build 50 GW of hydro-power projects. Most of these projects are in the Himalayan region and in the North-

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57 The rate for the first 12 years has been set at US cents 26/kWh and 20/kWh for Photovoltaic and Concentrated Solar Power systems respectively, and US cents 6/kWh thereafter.

58 Chikkatur, Ananth P. et al. 2007, page 48.

59 The operating efficiency under Indian climate conditions will be a little lower.

60 Working Group on Power, 11th Plan, Planning Commission, Government of India.

61 CEA, Base paper for Workshop on Renovation and Modernization and Water Optimization in Thermal Power Stations, June 2009.

East part of India. Ironically, water flows in these areas are highly susceptible to changes due to global warming. To ensure promotion of private investment in these dams, the regulator has passed on the full hydrological risk to the consumers, with a high potential cost.

Similarly, the government is pursuing a massive program to build over 40 GW of nuclear power. The US-India nuclear deal bolsters the viability of these plans, since India lacks sufficient indigenous sources of fuel to meet them. The Indian government also has ambitious plans for the development of indigenous fast breeder reactors (a 500 MW plant is under construction) using thorium as fuel. But nuclear generation is also controversial because of its high cost, slow learning curve (in bringing down future costs), safety risks associated with waste disposal, fuel handling, and energy security. Given these barriers and the fact that India has built only 4,120 MW of nuclear capacity in the last 50 years, its plans seem more dubious than its other capacity projections.

Natural Gas Markets

Natural gas offers the greatest potential among conventional fuels as a short-term bridge to a low carbon economy. The Indian government has actively promoted and established institutions for upstream markets for gas.

Over the last decade, India has followed an aggressive policy of exploring its basins for hydrocarbons through its New Exploration and Licensing Policy (NELP). Since the inception of NELP, there have been more than 100 hydrocarbon discoveries, most of them being natural gas, totaling over 30 trillion cubic feet. These discoveries are expected to triple domestic supply of natural gas. In addition, India has been actively exploring avenues to import gas.

India has also set up a regulatory board to govern markets for hydrocarbons. The investment in gas transport and distribution is expected to be of the order of $20 billion. The open access of transmission pipelines is expected to encourage wider distribution of benefits of natural gas.

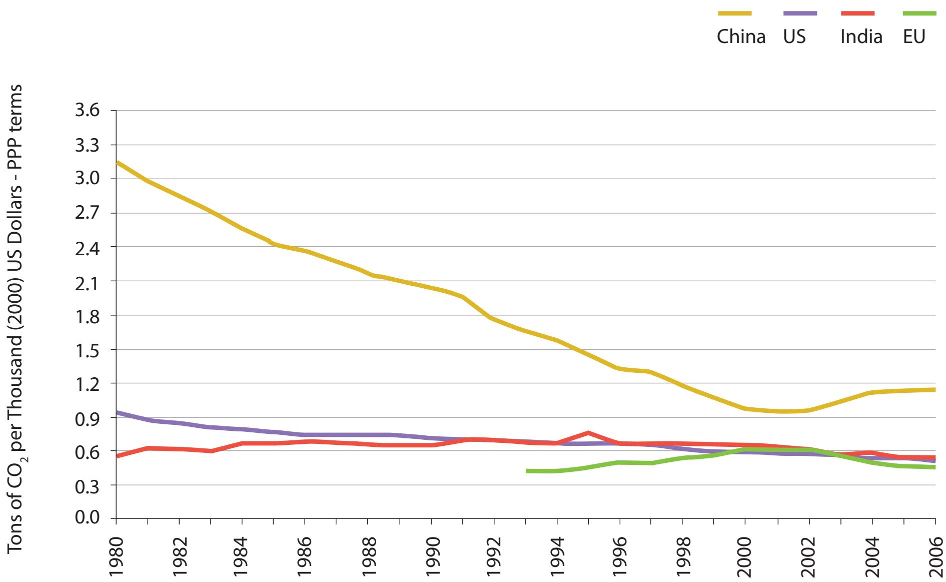
The Integrated Energy Policy (IEP) quantifies the Indian government's ambitions for gas in the Indian energy basket. The government predicts that the total primary energy supply from gas can increase five-fold in thirty years (from 38 mtoe in 2003-04 to 197 mtoe by 2031-32). As per the IEP, gas-based electricity generation is expected to increase from about 9 percent currently to about 16 percent, subject to domestic gas availability and cost/feasibility of gas imports. Even if only half of this capacity materializes, it would contribute 280 billion kWh per year. This would imply a reduction in CO_2 emissions of about 120 $MtCO_2e$ per year (about 10 percent of India's current CO_2 emissions) relative to coal-based electricity. This reduction would further increase if the gas were to be used in more efficient distributed co-generation.

Summary

Despite the aggressive and successful promotion of renewables, the net carbon intensity of electric supply growth will depend on a number of factors, not least of which is the penetration of super-critical coal technology. Wind capacity, as the least expensive eligible technology for states to meet their RPO, will likely continue to grow in the short term. If past trends are an indication, the government will likely fall short of its ambitious plans for nuclear, large hydro, and gas capacity additions. Subject to supply uncertainties, natural gas seems the most promising and least controversial fuel in the longer-term. Finally, the incentives offered by the Indian government for large-scale solar manufacturing sites seem to have proven attractive, but government plans to add solar electrical capacity may prove overly ambitious unless the projected but ambitious technological breakthrough that would reduce the cost of solar electricity comes true or there is substantial support through external funding.

IV Conclusion

The Indian economy exhibits some robust features of low carbon growth that make its overall energy and CO_2 intensity lower than that of China and comparable to that of the US (Figure 19). These elements include decreasing energy intensity of industries, high growth in services, an explosive growth in renewable capacity (half of incremental capacity since 2000, including hydro), and a relatively low carbon lifestyle, including low meat consumption and high use of non motorized and public transportation.



Source: Energy Information Administration, US Department of Energy

Figure 19: CO_2 Intensity of GDP – India, China, EU and the US

Current trends show greater promise of these trends continuing rather than reversing. Barring a significant shift from services to manufacturing, energy intensity ought to remain low or decrease further. The government has an ambitious and largely unprecedented suite of policies, at both the state and central level, to promote energy efficiency and DSM. These include dissemination of energy efficient lamps, appliance standards and labeling, and several capacity building initiatives. The energy efficiency initiatives are nascent, and will likely face some implementation and enforcement barriers in scaling up and in moving from a voluntary to a mandatory basis. Nevertheless, several programs seem to have seen initial gains.

Renewables penetration, particularly wind, stands out as the most significant carbon-reducing policy outcome, even though it has been partly motivated by energy security concerns. Here too, several laws and policies have been instrumental, and seem to be entrenched. These include state-level RPO in 19 states, tax benefits and subsidies on capital equipment for renewables, and a forthcoming Renewable Energy Law.

Future carbon intensity of energy use, however, will depend on coal policy, despite continued success in renewables. India needs to accelerate the transition towards super-critical technology, and improve the efficiency of power production and delivery. The government seems to be moving in this direction. In addition, the government has ambitious plans for gas, nuclear and hydro capacity additions. Of these, development of gas infrastructure offers the most convincing signs of future growth.

Notwithstanding these signs of optimism, India is by no means on an optimal path towards sustainable development. While the Indian economy has grown and poverty rates have declined, growth has not been sufficiently inclusive. Over 40 percent still lack access to electricity, 74 percent or rural India depend on biomass, and most of the growth in electricity consumption has served the upper and middle classes. Government policies in electric supply have focused on grid supply and expansion, which does not reach most of the poor. Significant opportunities for mitigation co-benefits still exist, particularly in the electricity sector. The carbon intensity of the electric sector is still one of the highest in the world, due to its unavoidable reliance on coal but also due to its inefficient coal plants and lossy distribution systems.

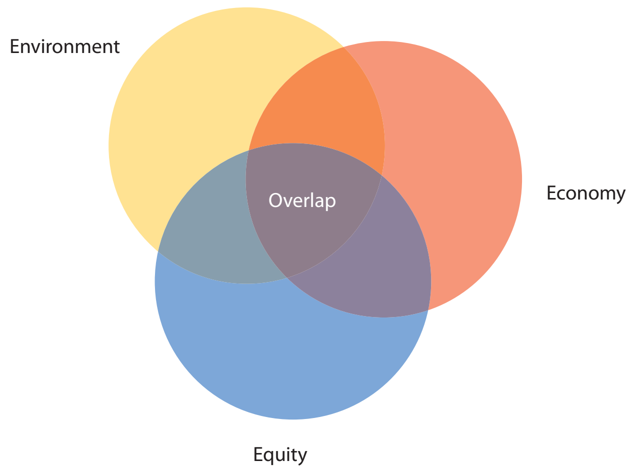


Figure 20: Sustainable Development Space

It seems apparent that within the broad confines of growth, equity and climate mitigation, the Indian government has not yet actively identified and pursued areas of overlap (Figure 20). The aggressive promotion of off-grid, rural solar-power lighting schemes, clean cookstoves, public transportation and safe infrastructure for non-motorized modes of transportation in non-metropolitan cities are but a few such examples. In addition, local environmental concerns, which have been outside the scope of this report, merit equal consideration in shifting towards an optimal development path.

Recent plans to link the National Rural Employment Guarantee Scheme with programs to promote rapid increase in forest cover are a realized example of this type of action. This would create employment for the rural poor, improve the local environment as well as create a carbon sink, and also stimulate the economy by stimulating rural demand.

Institutional capacity will also constrain effective policy implementation, even with more aggressive and sustainable policies. The widespread dissemination and long-term support of energy efficient products and off-grid renewables, for example, will likely require stronger enforcement of regulations, training, and maintenance infrastructure. Expanding the sphere of economically feasible options with the aid of external funding / technology can increase the overlap space for India (and other developing countries). This can allow faster achievement of development objectives while substantially meeting the climate challenge.

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The need for an international climate change agreement has never been more urgent. India contributes less than 5 percent of global greenhouse gas (GHG) emissions today with almost a fifth of the world's population. India's public stance of not undertaking carbon mitigation measures without assistance has received media attention, but much less is understood internationally about its energy trends and policies.

This report provides an overview of the energy-related carbon dioxide emissions trends in India in the industrial, transportation and residential sectors, their drivers, and influence of recent energy policies. Using comparisons to the US, EU and China, India's energy trends are placed in the context of its development needs.

India is on a relatively low carbon growth path, due to several features of the Indian economy. For instance, the energy intensity (energy use per unit of GDP) of the Indian economy is lower than that of both China and the US. Despite coal's dominance in energy, India has among the highest penetration rates of renewable energy capacity in the world, largely in response to policy incentives.

With one-third of the world's poor and over 40 percent of its population without electricity access, India needs significant growth in energy. However, recent growth has not been sufficiently equitable nor environmentally sustainable. Sizable potential for low-carbon energy growth is as yet untapped. A constructive dialogue between developed countries and India (and other developing nations) is essential to encourage these trends and direct assistance towards the needs of the poor. This report attempts to inform such a dialogue.

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