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Switched-on India:

How can India address climate change *and* meet its energy needs?

By Tim Gibbs

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Tim Gibbs was formerly a researcher in the climate change team at ippr. Prior to that, Tim worked for the press office of the International Labour Organisation in Geneva.

Abbreviations and glossary

+5	The five developing countries involved in the Gleneagles dialogue on climate change: Brazil, China, India, Mexico, South Africa
AT&C losses	aggregate, technical and commercial losses
CCS	carbon capture and storage
CDM	Clean Development Mechanism
CO_2	carbon dioxide
EBRD	European Bank for Reconstruction and Development
EU	European Union
EU15	The 15 member states that made up the European Union before enlargement in 2004
EU ETS	European Union Emissions Trading Scheme
G8	The group of eight leading industrial countries – Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, the United States of America
G77	The largest negotiating bloc of developing countries in the United Nations. Although there are now 131 countries in the bloc, the name G77 was retained because of its historical significance.
G.cal	giga calorie
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	greenhouse gas
IEA	International Energy Agency
IFI	International Financial Institution
IGCC	integrated gasification combined cycle [a type of coal power plant]
IP[R]	intellectual property [rights]
JI	Joint Implementation [mechanism]
km	kilometre
Kwh	kilowatt hour
LPG	Liquefied Petroleum Gas
Mwh	megawatt hour
MNES	Ministry of Non Conventional Energy Sources [NB recently renamed the Ministry of New and Renewable Energy, but the old title is retained in this paper]
Mt	million tonnes
$MtCO_2$	million tonnes of carbon dioxide
$MtCO_2e$	equivalent of one million tonnes of carbon dioxide
Mtoe	equivalent of one million tonnes of oil
MW	mega watt
ODA	overseas development aid
OECD	Organisation for Economic Cooperation and Development
ppm	parts per million [a measure of atmospheric concentrations]
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
SDPAM	sustainable development policies and measures
SME	small and medium enterprise
tCO_2	tonne of carbon dioxide
TRIPS	Trade Related Aspects of Intellectual Property Rights
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary and recommendations

Climate change is an issue of social justice – particularly in developing countries. If the world is to avoid disastrous climate change while at the same time reducing poverty, then developing countries will need access to low-carbon fuels. Currently, however, these countries lack plentiful supplies of cheap, 'clean' energy.

Developing countries need access to energy if they are to reduce poverty. Energy is the motor of economic growth and access to electricity should be universal. Historically, both developed and developing countries have met the vast majority of their energy needs by burning fossil fuels.

The transition to a low-carbon economy can be made, but it will be costly. Estimates suggest that it might cost an additional US$30 billion per annum to de-carbonise power supplies in countries outside the OECD (Organisation for Economic Cooperation and Development).

India is a country that acutely illustrates the nature of the challenge involved in developing its economy and preventing dangerous climate change. India's economy is growing at the rate of 9 per cent per annum, while pumping out large amounts of greenhouse gases (GHG). Yet the vast majority of the population literally live in darkness. Almost half of India's households do not have electricity, and women and girls spend a total of 80 billion hours each year collecting firewood, a fuel that damages the lungs of 24 million adults. It will cost US$130 billion simply to ensure that all Indian households enjoy access to electricity by 2030 – a cost that would rise if this power were to come from clean fuel sources.

India's dilemma raises significant questions of social justice. First, in a profoundly unequal world, how much effort should each country contribute to the protection of the global atmosphere? Second, what policy architecture and mechanisms can be devised to reach climate goals and who will pay for these policies?

Findings

India's GHG emissions will grow in the first decades of the 21st century because of the country's rapid economic growth and poverty alleviation efforts.

India's carbon emissions will grow exponentially in the first decades of the 21st century.
With economic growth targeted at 7 to 8 per cent, a four-fold energy increase, and thus an associated increase in emissions, is expected in the next 25 years.

India's emissions will rise as poor households gain access to energy and are lifted out of poverty.
Economic growth could bring universal access to the 56 per cent of the population – some 80 million households – that currently lack electricity provision. Studies suggest that around 40 per cent of emissions growth will be caused by policies promoting universal electricity provision, while transport emissions will account for just under 30 per cent of emissions growth.

Coal will continue to account for at least 40 per cent of India's total energy supply, even if the provision of renewable energy is rapidly expanded.
In the best-case scenario, in which renewable energy is expanded forty-fold, CO_2 emissions could rise from 1 billion tonnes per annum to 3.9 billion tonnes per annum by 2031/2. Under energy projections that assume an even higher rate of coal use, CO_2 emissions could rise to 5.5 billion tonnes per annum by 2031/2.

Nevertheless, the Government of India is concerned by climate change.

There is concern not least because India's poor, rural population will be hit hard.
Seventy per cent of the country's population live in rural areas and 60 per cent work in agriculture. Crop yields could decrease by up to 30 per cent by the mid 21st century due to climate change. Himalayan glaciers are among the fastest retreating in the world. Loss of the glacial melt-water which feeds the River Ganges, Indus and Brahmaputra river basins, 37 per cent of India's irrigated land, could cause water shortages for 500 million people.

The Indian government has shown some commitment to decarbonising its economy by diversifying sources of energy supply away from fossil fuels and improving energy efficiency.
Apart from climate change concerns, reasons to take these actions include:

- The difficulty of meeting India's burgeoning energy needs: there is a gap of 7.3 per cent between energy demand and supply.
- Concerns around energy security: in 1991, around 18 per cent of India's total primary commercial energy supply was imported; by 2004-5 this had reached 30 per cent.
- There are competitiveness concerns too for some industries because inefficient, high-cost energy services can raise the price of Indian goods traded on the world market.
- GHG emissions can also cause local environmental and health problems: particulate levels, for example, caused by traffic congestion, are above legal levels in Delhi, Hyderabad, Mumbai and Kolkata.

Various parts of the Indian government have discussed taking on challenging decarbonisation goals.
President Kalam has said that India should strive for 'energy independence' and require that zero-carbon energy (including renewables, large hydro, nuclear and traditional biomass fuels) should make up 25 per cent of India's energy supply by 2030.

The Ministry for Non-Conventional Energy Sources has suggested that renewables should account for 10 per cent of the power generation capacity that is installed between 2007 and 2012.

Many individual states are taking action to generate a proportion of electricity from renewable power sources. For instance, Karnataka has set a target of renewables making up 5-10 per cent of state electricity supply and is providing appropriate subsidies to ensure this target is met.

India is developing a modern renewables energy sector.
Renewables account for around 6 per cent of total electricity generation capacity and India has the fourth largest wind power industry in the world.

There are significant opportunities to set key sectors of the Indian economy on a low-carbon growth path.

There is the opportunity to rapidly expand decentralised, renewable electricity.
The Indian government's latest rounds of reforms to the electricity sector give independent power producers a greater role. These reforms have also allowed State Electricity Regulatory Commissions to specify that a percentage of power comes from renewable sources.

The Indian government's Planning Commission believes that, because of the widespread and endemic power shortages in many states, universal electricity provision is likely to be achieved through decentralised energy provision. The provision of green, decentralised electricity could make savings of 14-100 $MtCO_2$ per annum.

Significant emissions savings could also be made through the provision of clean cooking fuels.
The provision of cooking fuels to poor households will account for much growth in energy use. There are opportunities to provide clean, cheap, decentralised energy sources, such as modern biogas and Liquefied Petroleum Gas cooking fuels.

Large energy efficiency savings are possible in India, particularly in the electricity sector.
Forty per cent of grid electricity is unbilled. Some is given for free and a significant proportion is pilfered, yet subsidised electricity often does not reach the poorest sections of society. The Indian government's restructuring of the electricity sector could reduce financial losses and make significant energy savings.

Significant energy efficiency savings are possible in other parts of the economy.
The commercial and residential sector could make energy savings of 25 to 50 per cent. The Indian government is developing policies to encourage these savings such as by legislating and enforcing rigorous building standards and product labels.

Small and medium enterprises, such as steel rolling mills and textiles factories, often use highly energy-inefficient technologies, while the large energy-intensive industries operating in competitive global markets generally use highly energy-efficient technologies. However, there is much opportunity to improve the poorer performing plants in these sectors.

India's energy needs in the transport sector are set to rise exponentially in coming decades as households are lifted out of poverty. Donor support could help to dramatically reduce India's emissions.
From 2001 to 2031, energy consumption is projected to increase fourteen-fold. However, the Indian government's Integrated Transport Policy might make savings of 15 per cent against business-as-usual growth projections. The Indian government is taking forward a number of overlapping policies that will significantly reduce emissions. Cleaner fuels such as Compressed Natural Gas and biofuels are being used; standards improving the energy efficiency of vehicles have been mandated; and the Government is seeking to prevent a shift from public to private forms of transport.

However, the Indian government is cautious about making international commitments.

Despite expected dramatic economic growth, India will remain a poor country with a small per-capita carbon footprint.
India's per-capita energy usage is one sixth of the global average. Moreover, around one third of the total amount of energy India uses comes from traditional renewable fuels such as firewood and biomass.

Even allowing for India's exponential growth in energy demand, the country's per-capita carbon footprint will still be small. India's energy use per capita in 2030, even under high-emissions growth scenarios, will be lower than the global average in 2004. And 7 to 12 per cent of India's fuel needs will still be met by traditional renewable sources in 2031/2.

India will find it costly to take many opportunities to reduce emissions.
One study has suggested that India could reduce CO_2 emissions by 394 million tonnes as part of a global effort to prevent dangerous climate change. (In comparison, India emitted around 1 billion tCO_2 per annum in 2000 and emissions might rise to 5.5 billion tonnes in 2031/2.) Only 12 per cent of these reductions would be cost-free; approximately three-quarters of these savings would cost more than US$10 per tCO_2.

Calculations by the Indian government suggest that investment to reduce emissions by 550 $MtCO_2$ in the steel, cement and power sectors might cost US$25 billion; this sum is similar to the Government's planned expenditure to meet its social development goals.

Nevertheless, if a global agreement were reached to stabilise GHG at 450ppm CO_2e by 2050, a level that has a reasonable chance of avoiding dangerous climate change, and an equitable global framework were agreed to meet that target, India could still have significant 'headroom' for economic and emissions growth.

Under a business-as-usual scenario, India's emissions could grow by around 650 per cent above 1990 levels. Under a scenario in which countries are awarded equal per-capita emissions rights (that is, where each person in the world can emit the same amount of GHG), India's emissions would grow to around one-third of the business-as-usual scenario, reaching 206 per cent above 1990 levels. Under a multi-stage scenario, where emissions reductions are based on the level of economic development reached, India's emissions could grow by two thirds of business-as-usual, reaching 410 per cent above 1990 levels.

However, India's pattern of economic development would still have to shift significantly to a low-GHG emissions growth path, which could be costly and would require support from the international community.

Recommendations

Governments from the industrialised world should agree targets as part of negotiations on a successor treaty to the Kyoto Protocol that set the world along a path to prevent dangerous climate change.

To date, industrialised countries' action to combat climate change has been inadequate. The USA, the world's largest polluter, has not ratified the Kyoto Protocol. And the European Union is not on track to meet its Kyoto Protocol target of cutting GHG emissions by 8 per cent from 1990 levels by 2012.

However, the European Union has now committed itself to reducing its GHG emissions by 20 per cent below 1990 levels by 2020 unilaterally and by 30 per cent if an international agreement is reached. The 30 per cent emissions reductions would represent – only just – the proportionate effort that the EU needs to make if global GHG emissions are to remain within levels that may avoid dangerous climate change.

At the 2007 G8 summit, all G8 leaders agreed that the UN climate process is the appropriate forum for negotiating future action on climate change and that all major emitting countries would have to come to a global agreement by 2009. The G8 also agreed to seriously consider at least halving emissions from 1990 levels by 2050.

Further binding emissions cuts by developed countries are critical for demonstrating that the developed world is meeting its obligations to take the lead in mitigating climate change and for driving greater investment in low-carbon energy generation in developing countries through the Clean Development Mechanism.

Industrialised countries must develop policies that support India's emissions reductions efforts, as part of an equitable framework, under the UN climate process that prevents dangerous climate change.

In a context in which developed countries were to take on long-term, absolute emissions reduction targets, developing countries such as India should also take on appropriate targets, at least against business-as-usual projections.
This could reward and credit actions that India is taking to reduce its emissions. In the 1990s, for instance, India reduced its emissions against expected business-as-usual growth by 111 $MtCO_2$ (by comparison, the UK's CO_2 emissions fell from 592 $MtCO_2$ per annum in 1990, to 554 $MtCO_2$ per annum in 2005).

International emissions trading schemes should also be reformed to better support and credit India's sustainable development efforts.
Currently, India receives some low-carbon investment through international emissions trading. The Clean Development Mechanism (CDM) was established so that developed countries that fall under Annex I of the Kyoto Protocol can pay for emissions reductions in developing countries rather than making cuts at home. India has done relatively well from the CDM, gaining the majority of these project credits, worth 35 $MtCO_2$ in 2005.

However, the CDM only rewards individual, isolated projects that have few transformational effects. The CDM should be reformed so that it better supports broader sustainable development policies and programmes in developing countries.

India's emissions reductions efforts should be better supported by the international community.
India receives financial support through various multilateral and bilateral funds, by far the largest being the Global Environment Facility, which will, globally, disburse US$3.13 billion between 2006 and 2010.

However, such financial flows are inadequate. The Stern Review estimates that, worldwide, low-carbon investment requires an additional US$45 billion per annum. The World Bank suggests low carbon investment to developing countries requires additional investments of up to US$30 billion per annum. This requires that the Global Environment Facility is expanded ten-fold. But new funding flows to meet the climate change challenge must be additional to developed countries' pre-existing commitments to reduce global poverty.

Multilateral and national aid donors in the industrialised world should help the Indian government deliver cheap, low carbon energy to its population through decentralised systems of energy provision.

International donors have an important role to play in driving through power sector reforms that support cheap, low-carbon energy provision.
International financial institutions already support the energy sector. For instance, the World Bank estimates that it committed US$12.3 billion in support to the energy sector in India and China between 1990 and 2005. The UK government also committed hundreds of millions of pounds in technical assistance to Indian power sector reforms in the 1990s. Publicly mandated Export Credit Agencies also play a vital role in underwriting energy investments made in developing countries.

However, renewable energy investments account for less than 10 per cent of the World Bank's energy sector portfolio and only 1 per cent of Export Credit Agency support. There are also justifiable concerns within India that international donors over-emphasised financial discipline and the liberalisation of the electricity sector during the 1990s. Imposing financial discipline is problematic when so much of India's population is very poor: research suggests that around 50 per cent of Indian households would not be able to pay for electricity if domestic tariffs were set at commercial prices.

International financial institutions should phase out investments in fossil fuels, take on aggressive targets to promote the funding of renewable projects, and adjust the rules that discourage investments in low-carbon technologies.

Programmes from these institutions should help the Indian government to devise transparent policies and subsidies to provide clean, cheap electricity to the millions of households that lack this basic requirement, instead of encouraging State Electricity Boards to undertake financial austerity programmes.

The international community should be prepared to encourage the deployment of cleaner coal technologies as and when these become

technically available because coal will continue to account for a significant proportion of India's energy supply.
The US, UK and EU are looking to develop various partnerships with the Indian government to develop demonstration power plants that use cleaner coal and integrated gasification combined cycle (IGCC) technologies. Knowledge-sharing projects are also being developed on carbon capture and storage (CCS) technologies.

However, the OECD countries and the EU could and should play a greater leadership role in piloting these technologies. Given that nearly all coal-fired power stations in OECD countries are scheduled to be decommissioned by 2030, national and EU policy should mandate that any new plants are built 'CCS ready'.

The international community must also develop clean coal financing facilities, should these advanced technologies prove technically viable. If clean coal technologies are not deployed until they become commercially viable, India may be locked into a high-emissions economic growth trajectory.

Another challenge is to ensure that low-carbon technology is transferred from industrial countries to India and other developing countries. Restrictive intellectual property rights (IPR) arrangements can prevent the transfer of low-carbon technologies. Effective technology transfer also depends on ensuring developing countries gain access to technical knowledge in order to develop their own technological capacity.
OECD countries should double global public energy research and development (R&D) funding to around US$20 billion so that a diverse portfolio of low-carbon technologies can be developed. Worldwide, financial incentives (such as capital grants) to encourage the deployment of technology should be increased by a factor of between two and five from current levels of US$33 billion, a significant proportion of which should be spent in developing countries

Another challenge is to develop international partnerships between public and private sectors as well as IPR arrangements that allow the development of new technology and its transfer to developing countries. International collaborative research and development programmes would have the benefit of transferring intellectual property in terms of knowledge and technological capacity. A global research alliance could be established as a way of linking development objectives with the current, commercially driven IPR framework. A strong precedent for international collaboration on R&D was set by the Consultative Group on International Agricultural Research. Created in 1971, by the UN and the World Bank, it now has more than 8500 scientists working in more than 100 countries, drawing together the work of national, international and private sector organisations.

Aid donors should aggressively promote energy efficiency in India.
Although energy efficiency projects often bring net savings, the private sector and government in India often lack the capital to make investments into what is considered to be a non-core activity. Thus energy service organisations are inadequately funded – for instance, the Indian Bureau of Energy Efficiency only had five professional staff members in 2005. Multilateral and national donors in the industrialised world should provide energy efficiency funds and also develop the capacity of Indian government energy service organisations.

Introduction

The climate change debate is approaching a critical juncture. The first commitment period of the Kyoto Protocol, which established binding emissions reduction targets for industrialised countries, will expire in 2012. Negotiations to establish the emissions reductions commitments that follow thereafter will have to be concluded by 2009. If negotiations stall, the Kyoto emissions trading market, the principle means by which emissions reductions are achieved, will falter, and the international community's plans to combat climate change will lie in ruins.

The economic growth of the major developing countries poses a difficult challenge. On the one hand, United Nations negotiations have established that countries should act in a way that is consistent with their responsibility for climate change as well as their capacity to do so. Thus developed countries should lead, given their historical contribution to greenhouse gas (GHG) emissions and the economic development they have enjoyed as a result. The Kyoto Protocol established that only industrialised countries, which fell under Annex I of the treaty, take on emissions reduction targets.

On the other hand, there remains the task of ensuring that the major developing economies such as India and China have access to the most efficient, lowest carbon technologies, because they will make huge energy infrastructure investments in coming years. The International Energy Agency (IEA) estimates that US$17 trillion of energy investments will be made globally by 2030. If current patterns of economic growth continue, carbon dioxide (CO_2) emissions could increase by 60 per cent over current levels (DEFRA 2006).

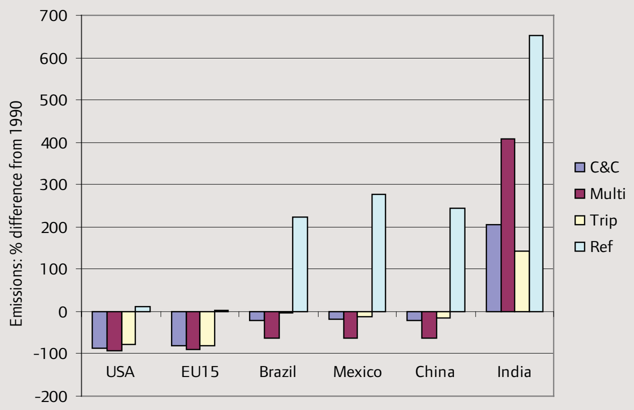
Box 1.0 and Figure 1.0 show how emissions reductions have to decrease worldwide in order to stabilise GHG emissions

Box 1.0: What emissions reductions might countries have to make to avoid dangerous climate change?

Hohne (2006) has provided indicative figures of the emissions reductions efforts different countries might have to make to stabilise atmospheric GHG concentrations at 450 ppm CO_2e by 2050 – a target that has a reasonable probability of the world avoiding dangerous climate change (Baer 2006). He shows how different countries might fare under various methods of attempting to divide the emissions reduction burden in an equitable manner:

- Under a contraction and convergence (C&C)* scenario countries are awarded equal per-capita emissions rights (that is, each person in the world can emit the same amount of GHG).
- The triptych approach takes into account differences in national circumstances: essentially that some countries are the 'workshops of the world', with large energy-intensive industries that have high CO_2 emissions.
- The multi-stage approach allows countries at different stages of economic development to take on different emissions reductions commitments. The least developed countries would have no commitments; in the second stage, countries would develop climate change objectives in their sustainable development policies; next, countries would take on energy-intensive targets; and industrialised countries would take on absolute reduction targets.

Figure 1.0: The emissions quotas required to stabilise atmospheric concentrations at 450 ppm CO_2e by 2050, under different burden-sharing scenarios



Source: Hohne 2006: 171

'Ref': The expected growth in emissions under business-as-usual expectations; 'Trip': emissions quota under the triptych methodology of sharing the reductions burden; 'Multi': emissions quota under the multi-stage methodology of sharing the reductions burden; C&C: emissions quota under the contraction and convergence methodology of sharing the reductions burden

These scenarios or approaches are important: they indicate that under a global framework that equitably shared the burden of making emissions reductions, India still has space to emit GHG during the course of its economic growth. This is particularly the case under the C&C and multistage formulae, which make particular allowance for India's large population and comparative poverty.

Under the business-as-usual reference scenario, emissions would grow by around 650 per cent above the 1990 baseline. Under the C&C emissions reductions formula, emissions would only grow by around one third compared with the business-as-usual scenario, reaching 206 per cent above the 1990 baseline. Under a multistage formula, emissions would grow by two thirds, reaching 410 per cent above the 1990 baseline.

Nevertheless, India's pattern of economic development would still have to dramatically shift to a low GHG emissions growth path, and this would require support from the international community.

*Contraction and Convergence (C&C) is trademarked to the Global Commons Institute (GCI). See www.gci.org.uk/briefings/ICE.pdf concentrations at levels at which we have a reasonable chance of avoiding dangerous climate change.

Structure of the report

This report examines the development dilemma that India faces. India has an extremely large economy and a rapid rate of economic growth, so will emit large amounts of GHG. However, the population overall is very poor, and development will require access to basic energy services; meanwhile the Government is very nervous of taking on costly decarbonisation commitments. The first section of this report tackles this fraught issue head on.

The second section argues that, even if India has taken a staunch position against taking on climate commitments on the international stage, it has undertaken a number of actions at cost to itself which will decarbonise the economy. Better still, there are many more low-cost opportunities to cut India's emissions to levels that will prevent dangerous climate change.

Nevertheless, the cost of decarbonising the Indian economy will be significant. Section three considers the policy frameworks through which the international community might address this issue.

The final section considers how the international community can help India devise policies that reduce emissions in rapidly growing parts of the economy, particularly in the power generation, electricity distribution, and transport sectors.

A number of interwoven themes thread through this narrative. First, in a profoundly unequal world, how much effort should each country contribute to the protection of the global atmosphere? Second, what policy architecture and mechanisms should be devised to reach climate goals? And finally, who will pay for these policies?

1. India's development dilemma

Debates around climate change and development are extremely fraught. This section addresses the associated arguments head on.

The nub of the issue is that India faces a development dilemma. On the one hand India is extremely vulnerable to climate change. Climate change threatens to undermine development efforts and reverse India's goal of bringing its population, which predominantly lives in rural areas, out of poverty. Government expenditure on rural development is large and could be overwhelmed by disastrous climate change.

However, Indian policymakers demand 'space for growth' in a world constrained by how much carbon it can safely emit. All measures show that economic development and human well-being closely correlate with access to energy. Indian policymakers argue that in a world shaped by industrial countries, it is not India's 'fault' that – just like in many developed countries – fossil fuels provide the predominant source of India's energy. In any case, India is much poorer and has much lower per-capita emissions than industrialised countries and the other large developing countries. In international negotiations India has been extremely reluctant to take on emissions mitigation commitments.

Nevertheless, India's emissions are of great concern to the international community. India is a large country with a population of more than one billion and is set to experience staggering economic growth in the next decades. Thus, its contribution to climate change will have to be addressed in an equitable manner.

The impacts of climate change on India

Indian policymakers are acutely aware that India's 700 million rural population are dependent on agriculture and natural resources, which are vulnerable to climate change. Agriculture accounts for 35 per cent of Gross National Product and directly employs more than 60 per cent of the Indian population. Fifty-five million live in or around forests, and many people's livelihoods depend on this resource. The Indian government invests heavily in the rural sectors. The draft approach paper to the 11th national plan, which will run from 2007 to 2012, seeks to achieve agricultural growth of more than 4 per cent, with significant additional investments made in this sector. In the 10th national plan alone, from 2002 to 2007, the Indian Department of Rural Development spent a budget of US$13 billion (UK-India 2005, Planning Commission 2006b, Sethi 2006).

Historically, India has been vulnerable to weather-related disasters. For instance, droughts in 13 states in 2002 left India's 70 water reservoirs with just 47 per cent of their normal capacity. The desert state of Rajasthan called for £1.26 billion emergency funds to hit their drought-hit population (Relief Web 2002). In 2004, heavy rains left 11.5 million people homeless in the states of Assam and Bihar (WHO 2004). Malaria epidemics occur every five to seven years in some states, and an epidemic in 1998 killed 20,000 people (Bhattacharya and Garg 2006). Climate change will exacerbate all these risks.

Increasingly, state and national levels of Indian government, supported by the international community, are seeking to understand the impact that climate change will have on India. A joint study between the UK and Indian governments, concluded in 2005, which involved eight Indian research institutes, provides the first systematic assessment of India's vulnerability to climate change (UK-India 2005). It has been complemented by a recent report of the Intergovernmental Panel on Climate Change. Both emphasise the severe impacts that India will experience due to climate change. (See Box 4.1, p.29, on how India could adapt to climate change.)

The headline findings of recent research into the impacts of climate change on India include:

- The mean surface temperature will rise by 2.5–4.0 degrees C by the end of the 21st century if global atmospheric concentrations of CO_2 reach 575 parts per million (ppm) (UK-India 2005).
- Crop yields could decrease by up to 30 per cent in South Asia by the mid 21st century (IPCC 2007).
- A one-metre sea level rise could result in the loss of 7.5 million houses, displacing 7 million people, with 4,000 km of road lost. Further rises could adversely impact around a quarter of India's population who live in the coastal belt

Box 1.1: Planes, trains and auto-rickshaws: emissions for luxury and emissions for survival

India's Centre for Science and Environment takes a strong stand on equity issues. These excerpts are from one if its articles written in 2006.

'The fact is that global economic wealth… and emissions are highly skewed. The question is whether the world will share the right to emit or will it freeze inequities. The question is if the rich world, which has accumulated a huge natural debt by overdrawing its share of the global commons will repay it so the poorer world can grow, using the same ecological space.

'What do the ubiquitous auto-rickshaw and the plush aeroplane have in common? The auto-rickshaw is a symbol of democratic mobility… a source of income for the poor [drivers], which drive the not-so-well-off… Maybe [Indians] should reduce the numbers of auto-rickshaws and replace them with trains and buses, which carry more people… But the fact is that airline travel cannot be considered 'survival' emissions but are 'luxury' emissions. The fact is that the rich in the world have overused their environmental space (or pollution quota) and that the poor need to be compensated for this overuse.' (CSE 2006a)

(Infochange India 2002, UK-India 2005).

- Severe rainfall and flooding are likely over an extensive area, covering the Western Ghats mountain range and the NW Peninsula (Kumar *et al* 2006).
- Himalayan glaciers are among the fastest retreating in the world. Loss of the glacial meltwater which feeds the River Ganges, Indus and Brahmaputra river basins, which account for 37 per cent of India's irrigated land, could cause water shortages for 500 million people (WWF 2005, IPCC 2007).
- Warmer, wetter conditions are also likely to spread potentially deadly food- and water-borne diseases, especially diarrhoea and cholera (UK-India 2005).

India's climate footprint

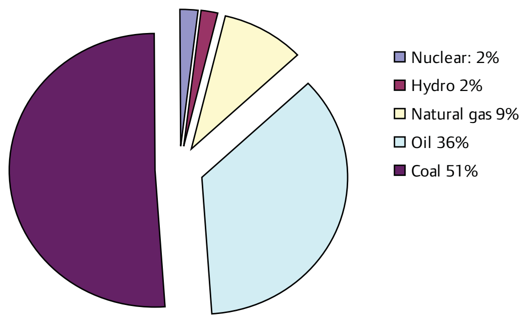
Concerns about equity loom large in the meetings, presentations and reports produced by Indian officials, non-governmental organisations (NGOs) and academics (see Box 1.1 above). Policymakers are well aware that their country will be hit by climate change; however, as India is poor, they are also wary of losing 'space for growth' by taking on climate change commitments.

Although fossil fuels dominate commercial energy usage, with coal accounting for the lion's share of energy generation, India's carbon footprint per capita is extremely low by global standards (see Figures 1.1, 1.3 and 1.4). India is extremely poor – even slightly poorer than many African countries such as Benin, Ghana and Malawi, which have a lower proportion of their population living below the poverty line of US$2 per day. Around 80 million Indian households, 56 per cent of the population, do not have electricity (see Figure 1.2).

Due to poverty, India generates 32 per cent of its energy from traditional renewable energy sources such as firewood and animal dung. The use of such sources of energy is estimated at around 155 million tonnes of oil equivalent (Mtoe) per annum, and the total annual commercial annual energy consumption is estimated to be around 327 Mtoe (KPMG 2006). Seven to 12 per cent of India's fuel needs will still be met by traditional renewable sources in 2031/2 (Planning Commission 2006a).

A primary concern for Indian policymakers is to improve access to energy, and the Government is committed to providing electricity

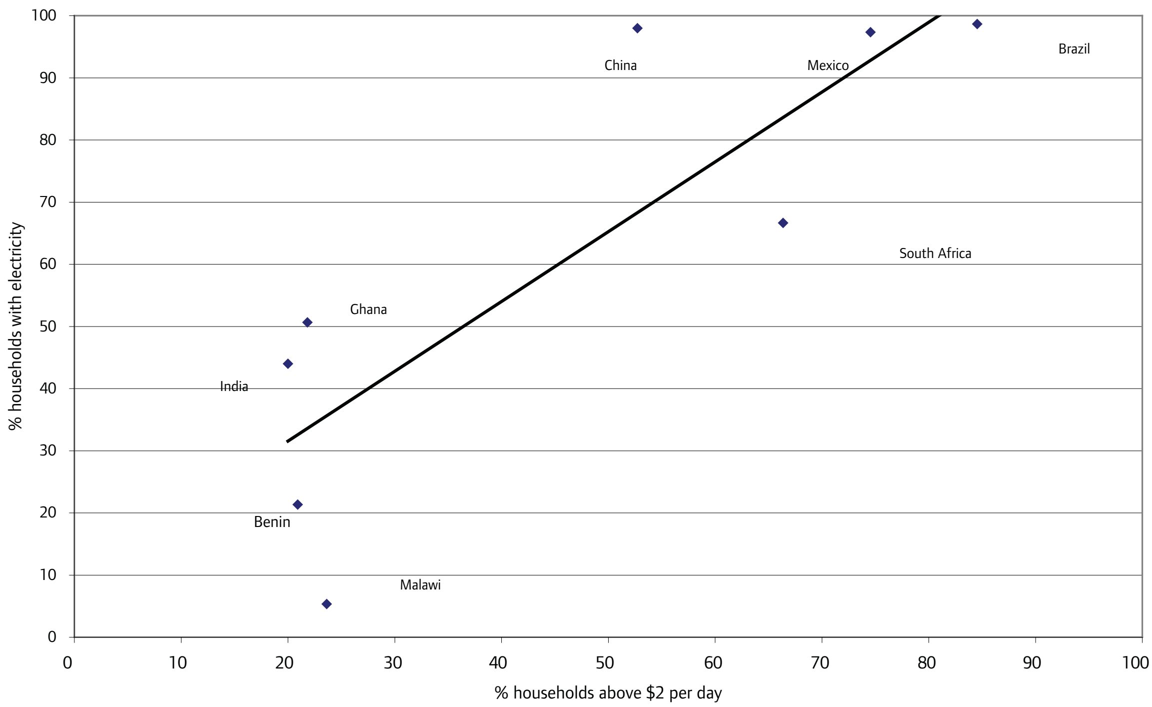
Figure 1.1: Primary commercial energy use



Source: KPMG 2006: 6

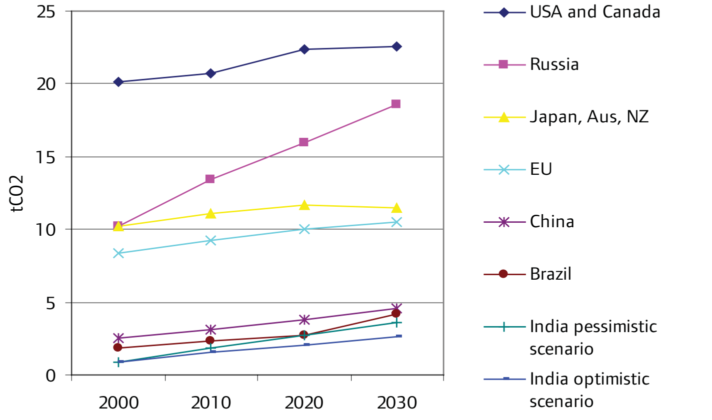
Note: Renewables account for 5 per cent of renewable electricity generation capacity. However, renewables account for less that 1 per cent of the electrcity than is actually produced. This is because many renewable technologies, such as wind turbines, operate intermittently and cannot function at 100 per cent capacity.

Figure 1.2: Poverty rate and household electricity access – trend line and selected countries



Sources: World Bank 2006: 51 and Dubash and Bradley 2005: 71

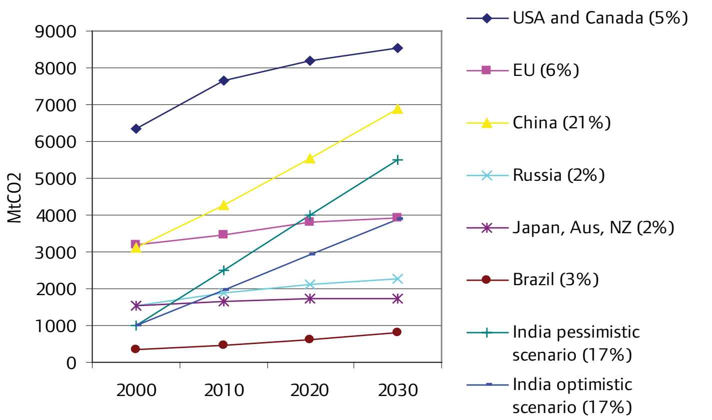
Figure 1.3: Per capita emissions for selected countries and regions of the world



Source: Kumar 2006: 6 and Planning Commission 2006a: 50

Note: Data for India taken from Planning Commission 2006a. Data for other countries taken from Kumar 2006 who uses 2002 IEA figures. Kumar's data for India shows a slightly lower emissions growth than that provided by the Planning Commission, but the trend line is very similar. More recent IEA reports have indicated that developing countries' emissions growth, particularly China's, might be even more rapid.

Figure 1.4: National emissions projections for selected countries (figure in brackets shows % of world population)



Source: Kumar 2006: 7 and Planning Commission 2006a: 50

Note: as for Figure 1.3

to all households.[1] There is a clear correlation between access to electricity and poverty reduction measured in monetary terms (shown in Figure 1.2). Indian policymakers argue that India's rapid economic growth could alleviate poverty; but these prospects are undermined by an energy supply crisis. The Indian Planning Commission estimates that power generation capacity must increase from 2007's rate of 160,000 mega watts (MW) to 800,000 MW by 2031/2 if growth rates of 7 to 9 per cent are to be maintained (Planning Commission 2006a). Apprehension about India's ability to meet this objective was behind the Planning Commission's Integrated Energy Policy report in 2006, in which the Prime Minister stated, 'The present energy scenario is not satisfactory… If India is to move to a higher growth rate… we must ensure reliable availability of energy' (Planning Commission 2006a: v).

Increased energy generation in response to the country's rapid economic and population growth will increase India's GHG emissions exponentially in the next decades. India currently emits 1 billion tonnes carbon dioxide (tCO_2) per annum; by 2031/32 this could rise to 5.5 billion tCO_2. That is similar to the United States' current level of emissions.

However, compared to per capita emissions in Kyoto Annex I countries, India's responsibility for climate change is modest, even when the country's rapid economic growth in the next decades is factored into calculations (see Figures 1.3 and 1.4). Assuming high coal use, Indian carbon emissions would only be 3.6 tCO_2 per capita in 2031/32. However, per capita emissions in 2004 were already 20 tCO_2 in the US and the global average was 4.5 tCO_2 that year (Planning Commission 2006a).

Equity in the greenhouse

Because India's per capita emissions are low, policymakers are reluctant to take on formal commitments to reduce the country's climate impact. Indeed, the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol are founded on the important principle of 'common but differentiated responsibilities': although the international community has a common responsibility to tackle climate change, the main burden falls on Annex I industrialised countries (G8 2005). Hence the Kyoto Protocol set emissions reductions targets for Annex I countries. Non-Annex I countries are included in climate mitigation efforts through the Clean Development Mechanism (CDM) – the financing facility that allows industrialised countries to pay to make emissions reductions efforts in developing countries rather than making them at home.

There have been a number of parallel dialogues (noted in the introduction) that discuss how major emitters in the developing world, particularly Brazil, China, India, Mexico and South Africa, might be able to reduce their emissions. These so-called '+5' countries have consistently argued that the principle of differentiated responsibilities means that: 'Developed countries should take the lead in international action to combat climate change by fully implementing their obligations of reducing emissions and providing additional financing and the transfer of

1. Universal electrification is a key political priority, which generates much controversy. In recent years, India's governments have given themselves ever more challenging targets. A recent statement from the Ministry of Power called for all households to be electrified by 2009. The description of the target in terms of households, and not villages, is important. While 87 per cent of villages are reported to be electrified (defined as electricity used for any purpose anywhere in the village), only 44 per cent of households have electricity. Electrifying households by the end of the 11th plan (2012), would require connecting 10 million households per year, ten times the rate of recent household connection (Dubash and Bradley 2005). Most recently, the approach paper to the 11th national plan sets a target of 'ensuring electricity connection to all villages and Below Poverty Line households by 2009 and round the clock power by 2012' (Planning Commission 2006b: 103).

cleaner, low-emissions and cost-effective technologies to developing countries' (G8 2005).

However, key Annex I countries have not led the way by reducing their emissions. The US, which is the originator of around one quarter of the world's GHG emissions, has not ratified the Kyoto Protocol to reduce greenhouse gases. Even Europe, the self-proclaimed leader on climate change, is on track to cut its 1990 GHG emissions by around only 1 per cent in 2012, compared with its Kyoto target of 8 per cent emissions reductions (EEA 2006).[2]

Nor have developed countries made significant funds available to support low-carbon investment in developing countries. India receives the most financial investment that comes through international carbon markets. In 2005, it was expected that India would make emissions reductions equivalent to 35 million tonnes of carbon dioxide ($MtCO_2e$) per annum, which would be financed through the CDM. Nevertheless, the size of the CDM market is paltry when compared with the challenge of financing low-carbon development (Ellis and Levina 2005).

The Global Environmental Facility (GEF) is the largest source of multilateral financing for low-carbon technologies. In August 2006 the fund was replenished with US$3.13 billion for the next four years. However, a World Bank review suggests that funding would have to be increased by a factor of three to achieve sustained market penetration of near-commercial energy efficiency and renewable energy technologies. To meet the capital investment needs of new low-carbon technologies, resources would have to be scaled up by a factor of 10 or more (World Bank 2006).

India is also much poorer than the other rapidly developing countries in the '+5' who are engaged in G8-initiated Gleneagles Dialogue on climate change. The other four are designated as middle-income countries by the World Bank, whereas India is a low-income country. Asking India to adopt similar carbon constraints as them is therefore seen as unfair. For instance, the lion's share of India's GHG emissions growth will be due to policies to achieve universal electrification (see Table 2.1). Brazil, China and Mexico have electrification rates close to 100 per cent; India's stands at 56 per cent. African countries with similar poverty and electrification rates to India, for instance, have not been asked to take on climate change commitments (see Figure 1.2).

Therefore the Indian government has been much more cautious than richer, middle-income countries to discuss climate change. At the 2006 UNFCCC conference the Mexican Environment Minister 'expressed willingness to consider participation in [future] climate change regimes'. The Indian minister 'said several key Annex I countries had failed their [Kyoto] Protocol commitments, and described calls for developing countries to take on emissions commitments post-2012 as "shril", "surreal" and a "threat to poverty alleviation efforts"' (IISD 2006: 28).

Nevertheless, India's sizeable emissions footprint cannot be ignored. By 2031/2, India might pump out around 5.5 billion tCO_2 into the atmosphere per annum. The question that follows is how can the international community promote a sustainable development agenda that supports the Indian government's efforts to drive economic growth and eradicate poverty? These concerns are addressed in the following sections.

2. Under the Kyoto Protocol, Annex I countries could meet their entire emissions reduction target by making emissions reductions in developing countries rather than at home. However, in international negotiations, the EU had proposed that the majority of emissions (at least 4 per cent of the reductions) should be made at home. Industries that fall under the EU Emissions Trading scheme (EU ETS) are expected to abide by this principle.

2. Low-carbon development in India: prospects and possibilities

The Indian government – despite its hardline position against taking on commitments to reduce emissions in international climate change negotiations – has already taken many actions to decarbonise the Indian economy. This section maps the growth of CO_2 emissions in key sectors of the Indian economy, the scale and size of India's current decarbonisation efforts, and the potential to further reduce emissions to levels necessary to avert dangerous climate change.

In the coming decades, GHG emissions are projected to grow rapidly because of India's quick economic development, particularly as a high proportion of its energy comes from coal. However, Indian policymakers take a growing interest in promoting energy efficiency and renewables because the country's burgeoning fuel needs raise concerns around security of supply. Thus policies already tabled by the Indian government could significantly reduce the growth in emissions.

In addition, many more relatively low-cost options for reducing emissions are available in India. Studies suggest that if all these low-cost measures were taken, it would be possible to stabilise global atmospheric concentrations at levels likely to avoid disastrous climate change.

India's economic growth and energy needs

In the coming decades India's emissions will grow exponentially. With economic growth targeted at 7 to 8 per cent, energy requirements are expected to grow at 5.6 to 6.4 per cent annually, a four-fold increase over the next 25 years (KPMG 2006, Planning Commission 2006a).

Electricity generation will be the primary source of emissions growth. The Ministry of Power set a target of adding 100,000 MW of generation capacity over 2002 to 2012 (Planning Commission 2006a). Most significantly, the Indian government has the goal of universal electrification. It is estimated that some 56 per cent of households are not currently electrified. Additional generation capacity is also urgently required to meet electricity shortages. Blackouts, fluctuating voltage and erratic frequency are common. The gap between electricity demand and supply during peak hours averages at 11.7 per cent across India, and in some states has been as high as 25.4 per cent (Planning Commission 2006a, Dubash and Bradley 2005). This causes great difficulty to domestic consumers. Electricity shortages also have the potential to lower economic growth by more than 1 per cent (World Bank 2006).

Power is also required to fuel India's industrial growth, notably in the burgeoning cement and iron/steel industries. In addition, transport fuel demand is expected to grow rapidly. Most notably, motorbike usage has been growing exponentially, at a rate of 15 per cent per year in the past three decades: there were 0.5 million motorbikes in 1970/1, 2.5 million in 1980/1, 14.2 million in 1990/1, and 41.5 million in 2001/2. Over the same period, the number of cars on India's roads grew from 539,000 to 5.7 million – a growth rate of just over 8 per cent per year (Planning Commission 2006a).

India's decarbonisation efforts

Currently, fossil fuels, particularly coal, account for the bulk of India's energy supply (see Figure 2.0). However, the growth in energy demand has driven the Government of India to increase renewable power generation as part of a strategy of diversifying sources of supply and promote energy efficiency measures. Four drivers are particularly important:

- The Government is well aware of the difficulty of meeting its growing energy needs. Today, there is a gap between energy demand and supply of 7.3 per cent (Planning Commission 2006a).
- India is concerned about energy security. In 1991, around 18 per cent of India's total primary commercial energy supply was imported into the country; by 2004–5 this figure had reached 30 per cent. In particular, the Government is acutely aware of its growing dependence on oil, 72 per cent of which was imported in 2004–5 (Planning Commission 2006a, KPMG 2006).

Table 2.0: Projected emissions growth in selected sectors, 2000 to 2020*

Sector	2000 emissions (MMTCO_2)	2020 emissions (MMTCO_2**)
Electricity	427	1062
Cement	67	339
Iron/steel	66	300
Pulp/paper	6	13
Transport	97	547
Residential	47	80
Commercial	7	18

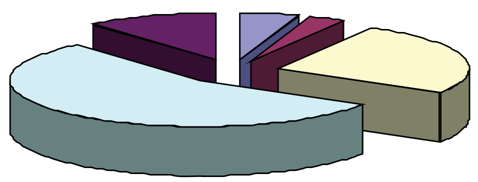
Notes: *These sectors account for around 80 per cent of India's total emissions; **MMT= million metric tonnes
Source: CCAP 2006: 14

- Concerns related to competitiveness also loom large. Inefficient, high-cost energy services can raise the price of Indian goods traded on the world market.
- The burning of fossil fuels, as well as being the principle cause of GHG emissions, also causes local environmental and health problems. For example, it has caused particulates to be well above legal levels in Delhi, Hyderabad, Mumbai and Kolkata (Planning Commission 2006a).

Table 2.1: Renewables deployed in India

Resource	Existing installed capacity
Wind	~4400 MW
Small hydro (up to 25 MW)	~1700 MW
Biomass power/cogeneration	~950 MW
Solar water heating	1.5 million square metres collector area
Biogas plants	3.8 million
Source: KPMG 2006: 25	

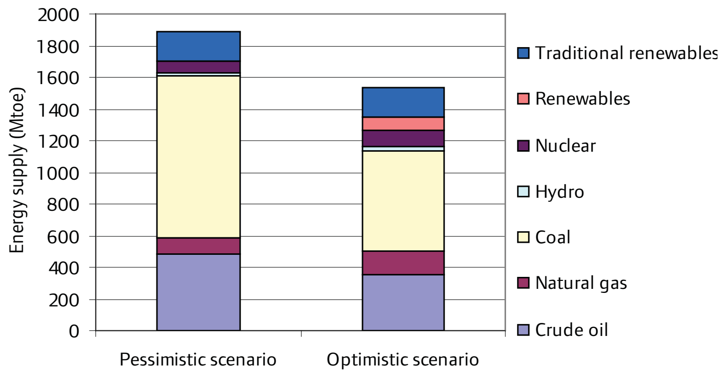
Figure 2.0: Electricity generation capacity, March 2006 (Total capicity= 124,310 MW)



Source: Mundy 2006: 5

Note: Renewables account for 5 per cent of renewable generation capacity. However, given that load factors (a measure of the output of a power plant compared with the maximum output it could produce) are very low – less than 17 per cent for wind farms – renewables make a much smaller contribution to India's commercial energy generation mix.

Figure 2.1: Fuel mix in 2031/2 under the Indian government's most optimistic and most pessimistic planning scenarios



Source: Planning Commission 2006a: 44

Notes: The difference between the energy supply needs in the optimistic and pessimistic scenarios is accounted for by energy efficiency savings. Traditional renewable fuels are biomass energy sources such as firewood and cow dung

These concerns have already led the Indian government to make significant efforts towards decarbonisation. The total spectrum of decarbonisation measures undertaken in the 1990s – including energy conservation and gas flaring – is estimated to have saved 111 $MtCO_2$. For instance, improved combustion in coal firing plants slowed emissions growth by 2.5 million tonnes (Chandler *et al* 2002). Renewables play a small but significant role in India's energy mix. The Ministry of Non-Conventional Energy Sources (MNES)[3] estimates that renewables account for 7,100 MW of generation capacity, around 6 per cent of total installed generation capacity (see Table 2.1 and Figure 2.0). India is the second largest biogass and fourth largest wind power generator in the world.

Many of the decarbonisation efforts that the Indian government has made have been costly. It is difficult to place an exact figure on the total financial support provided by the Government and tax payers. Nevertheless, a few figures from the power sector indicate the additional costs of renewables: the MNES estimates that approximately 2,400 MW of renewable power was installed in 2005–6, a total investment of around US$2.4 billion, with the Indian government providing US$0.1 billion financial support (MNES 2006). The Indian government also estimates that some of the emissions reductions undertaken in the power sector are extremely costly. For instance, the emissions reductions made by wind turbines cost US$63 per tCO_2 (Sethi 2006).

Decarbonisation commitments made by the Indian government

Various parts of the Indian government have taken on policies and targets that are projected to reduce emissions against business-as-usual expectations in the coming years. The MNES has submitted that 10 per cent of additional power capacity built during 2007–2012 should come from renewables (MNES 2006).[4] In addition, almost half the State Electricity Regulatory Commissions within the country have taken on commitments and policies to produce a proportion of electricity power from renewables. For instance, Karnataka has set a target of renewables making up 5–10 per cent of state electricity supply and has provided appropriate subsidies to ensure this target is met. Other policies, such as the 2005 National Steel Policy and 2002 Integrated Transport Policy, might make savings of 5 per cent (17 $MtCO_2$) and 15 per cent (97 $MtCO_2$) against

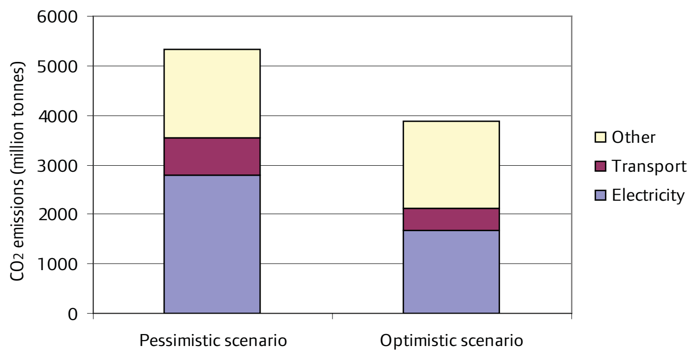
3. The MNES has recently been renamed the Ministry of New and Renewable Energy. For the sake of convenience, the old title is retained here.
4. This submission to the 11th plan had not yet been approved at the time this report was written.

business-as-usual growth projections (CCAP 2006: 14).

Most boldly of all, the President of the Republic, Abdul Kalam, stated 'energy independence is the lifeline of a nation', in his 2005 Independence Day Address (Kalam 2005: 2). In a subsequent speech he elaborated his ambition: by 2030, 'fossil fuel imports need to be minimised… [and] renewable energy has to be increased to 25 per cent against the present 5 per cent' (Kalam 2006: 3).

Dr Kalam takes a broad definition of renewable energy. His figures were taken from the most optimistic of the Planning Commission's energy supply scenarios, which suggested that in 2030: nuclear energy might make up 6.4 per cent of India's energy mix; large hydro power plants (with a capacity of over 25 MW) 2.2 per cent; renewables 5.6 per cent; and traditional biomass 12 per cent (Planning Commission 2006a). Figure 2.1 shows how this optimistic scenario compares with the most pessimistic of the Planning Commission's energy supply scenarios. In the most optimistic scenario, fuel efficiency dramatically increases and zero-carbon energy resources are developed extremely rapidly. (These are dramatic assumptions: many measures are likely to be very costly and renewable technology would be deployed at break-neck speed, increasing more than forty-fold.) The pessimistic scenario assumes that coal continues to be the main source of energy supply. Figure 2.3 shows the CO_2 emissions that would result from both these scenarios.

Figure 2.2: CO_2 emissions in 2031/2 under the Indian government's most optimistic and most pessimistic planning scenarios



Source: Planning Commission 2006a: 50

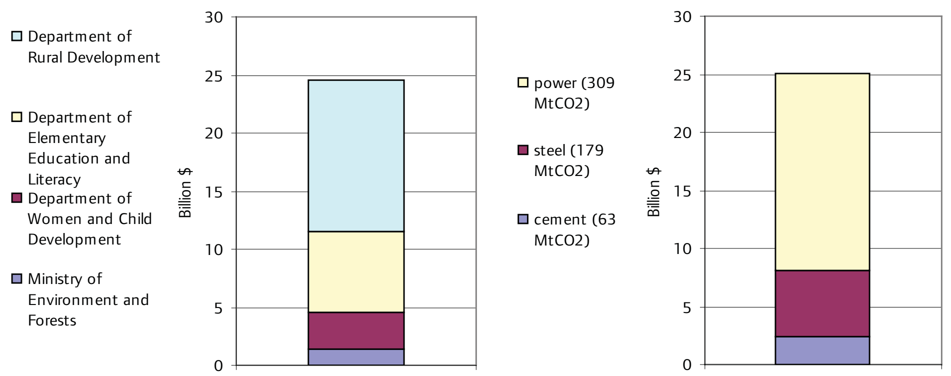
Further emissions reductions: possibilities and costs

It is much more difficult to ask, as part of a global strategy to avert dangerous climate change, what is the scale of additional effort that India might be able to make to reduce emissions? This raises fundamental questions of equity: how should the emissions reduction burden be divided between different countries? Also, these estimates cannot be exact because there are a range of variables to consider, including the changing science of climate change, the development of low-carbon technologies, and the patterns of economic growth. Nevertheless, it is likely that it will be costly to decarbonise India's economy. As a rule of thumb, the Stern Review suggested that low-carbon investments cost 15 per cent more than investments in 'normal', high-carbon, energy infrastructure, such as coal and oil fired power plants (Stern 2006b). The World Bank has estimated that, across all non-OECD countries combined, significantly 'de-carbonising' power production would require additional investments of up to US$30 billion per year (Sierra 2006).

One study, which has produced an indicative set of figures on the possibilities and costs of emissions reductions, is provided by the Center for Clean Air Policy (CCAP 2006). The study assumes that the US cuts its emissions to 1990 levels by 2020 and that the EU and other developed countries cut their emissions to 30 per cent below 1990 levels by 2020. (These emissions reductions are politically feasible, though not necessarily equitable.)

The CCAP study considers the emissions reductions options available in the major sectors of the Indian economy, and suggests that India might be able to reduce emissions by 394 $MtCO_2$ below business-as-usual projections. This would be equivalent to reducing emissions to 17 per cent below business-as-usual expectations.[5] (The study assumes that other major developing countries would make similar emissions reduction efforts.) Together, these actions would reduce emissions to levels that would be sufficient to stay on track to stabilise global atmospheric CO_2 concentrations at 450ppm.[6]

Figure 2.3: Additional investment requirements (2012–17) for transition to a low-carbon growth path in relation to selected government spending on development (2002–2007)



Source: Sethi 2006: 15

5. This study does not factor in the emissions reductions that India has made through policies implemented prior to 2000.
6. Stabilising emissions at 450 ppm CO_2 is roughly equivalent to stabilising emissions at 500 ppm CO_2e. There is a high chance that this stabilisation level may not avoid disastrous climate change (Baer 2006).

However, the CCAP study finds that many of the available emissions reductions opportunities identified in India are quite expensive. Only 12 per cent of the identified reductions have net cost savings; around three quarters of the savings cost more than US$10 per tCO_2. In one sense this carbon price is not prohibitively expensive, given that the carbon prices in the EU Emissions Trading Scheme have, at times, risen to Eur25/$33 per tCO_2. But such emissions reductions will still impose high costs on the Indian government and society, given that India might need to make extensive emissions savings.

A separate study (Sethi 2006) conducted by the Indian government underlines the magnitude of the costs to national society. The study calculates the additional investment requirements necessary to reduce emissions in the Indian cement, steel, and power sectors by 550 $MtCO_2$ against business-as-usual projections during the 12th national plan (2012–2017). (By comparison, the Indian Planning Commission [2006a] estimates that the nation currently emits around one billion tCO_2.) The study suggests these emissions savings might require investments worth an additional US$25 billion. This expenditure is equivalent to national government expenditure on social development (see Figure 2.3).

Taken together, these various estimates all suggest that decarbonising the Indian economy is likely to be expensive. This prompts the question of how the international community can develop policies that provide sufficient support for India to be able to make the emissions cuts necessary to avoid dangerous climate change – questions that are addressed in sections three and four.

3. Sectoral strategies for low-carbon development in India: an overview

There are great opportunities for the Indian government to develop sectoral policy frameworks that promote low-carbon, sustainable development across all of society.

The international community is well placed to play a vital supportive role, enabling India to provide accessible low-carbon energy to its citizens. It already plays a significant role in Indian energy sector investments. For instance, the World Bank Group estimates that it has committed US$12.3 billion to the energy sector in India and China from 1990–2005 (World Bank 2006).

This section argues that India's rapid economic growth provides an opportunity to transform energy services. In particular, there are great opportunities for renewable energy to play a much greater role in a decentralised system of energy provision. Nevertheless, fossil fuel will remain a mainstay of the Indian economy; thus, donors must take preliminary steps to develop cleaner coal technologies with Carbon Capture and Storage (CCS). There are also great opportunities to improve energy efficiency, as well as making emissions savings in the transport sector.

Providing clean energy for all – opportunities for decentralised energy

Universal electricity provision

The Indian government has set itself the daunting task of achieving universal electrification. It is estimated that currently around 56 per cent of households – some 80 million – are not electrified. This problem is particularly dominant in the countryside, with 67 per cent of rural households lacking access to electricity, compared with just 18 per cent of urban households (Dubash 2002a).

Current government policy prioritises bringing electrification to 125,000 villages currently without power, augmenting distribution networks to a further 462,000 villages, and electrifying the 55 million houses that are below the poverty line. Below-poverty-line households are connected free of cost and all other capital costs receive a 90 per cent subsidy (Planning Commission 2006a).

There is both a danger and an opportunity here. India's Planning Commission has said, 'Given the present widespread and endemic shortage of power in many states, special action is needed to facilitate and encourage decentralised distributed [electricity] generation' (Planning Commission 2006a: 100). There is a real possibility that diesel power will meet much of this need because fuel costs are low and extensive supply networks are already in place. However, research suggests that off-grid diesel generation would worsen India's carbon footprint and energy dependence, with diesel imports increasing by between 6 and 41 per cent.

Table 3.0: Indicative prices for off-grid power generation technologies

Technology	Price per kilowatt hour (KWh) (US cents)
Solar	20-94
Wind	3.6-11.7
Biomass	4-10
Diesel	10

Source: Dubash and Bradley 2005: 84

Off-grid renewables would also save 14–100 $MTCO_2$ per annum (Dubash and Bradley 2005). The price of renewable generation technologies could be competitive in certain circumstances. Off-grid renewables are not always much more expensive than off-grid diesel, as Table 3.0 indicates. The capital costs of renewable technologies could also be greatly reduced by large building programmes that brought economies of scale. Also, the economics of electricity power provision are extremely murky in India because of complex fuel tariffs and subsidies – indeed, it is possible that poor rural consumers would be entitled to subsidies that would make off-grid renewable energy provision possible (ibid). Finally, if international financial institutions (IFIs) properly supported the Indian renewable power sector – pushing pre-commercial technologies into the marketplace, achieving economies of scale, and crediting emissions reductions achieved by renewable power – then the financial picture would improve further still.

Clean cooking fuels

The provision of clean fuel for cooking is another major challenge. Some 70 per cent of the population, 625 million people, use traditional cooking fuels. In rural areas, the proportion is even higher: a recent study found that 96 per cent of rural households use biomass energy (wood and animal waste), 11 per cent use kerosene and 5 per cent use Liquefied Petroleum Gas (LPG). The human costs of using traditional fuels are immense. Eighty-five million households spent a total of 30 billion hours each year gathering wood for fuel. Burning these fuels can cause endemic health problems: 24 million adults suffer respiratory problems, with 17 million suffering from severe symptoms (Planning Commission 2006a).

The Indian Planning Commission has identified a number of simple policies that can provide clean, readily available cooking fuels through decentralised distribution networks. Modern biogas plants could meet some 30–40 per cent of rural cooking energy demand. Supply of LPG cooking fuel could be increased relatively easily. Studies suggest that only 13 Mtoe of consumption would need to be subsidised in 2030/1 to be able to ensure that poor households were able to buy LPG fuel. Removing the subsidy on kerosene fuel could also benefit poor households and improve environmental performance. Studies suggest that the majority of subsidised fuel does not reach the households it is intended to benefit. Instead, it is often illegally mixed with diesel fuel – a practice that has harmful environmental and health consequences (Planning Commission 2006a).

Reforming the electricity sector

Electricity is a 'concurrent' subject in India: both national and state government have jurisdiction over the sector. Under the 1948 Electricity Supply Act, vertically integrated State Electricity Boards (SEBs) were created, which controlled the generation, transmission and distribution of electricity. Most SEBs were financed entirely through state government loans and were essentially adjuncts to state energy ministries. These institutional arrangements allowed the rapid development of power services, with generation capacity increased fifty-fold from 1948–1991 (Dubash 2001).

However, the electricity sector failed to meet key environmental and social concerns, because government policy led to severe inefficiencies in the power generation and distribution process. Power purchase agreements entered into by SEBs allowed dirty, inefficient coal plants to provide electricity at the expense of cleaner generation technologies. Also, power transmission policy had led to the unconstrained use of electricity and thus financial melt-down. The agricultural sector was supplied with un-metered power in almost all states and farmers paid highly subsidised electricity bills on the basis of the declared horse power of their water pumps used for irrigation. This enabled politically powerful farming groups to inefficiently consume electricity and overexploit local groundwater resources.

Industrial and commercial users were required to cross-subsidise agricultural consumption, while receiving poor quality service. Industrial and commercial consumers responded by pilfering power and setting up their own, off-grid, so-called 'captive', power generation plants, which were often powered by dirty fuels. It has been estimated that captive power plants provide 30,000MW of electricity in India. These are often fuelled by coal, woody biomass, fuel oil and diesel, which are burnt in inefficient boilers (Gupta 2006). By opting out of mainstream grid electricity, these consumers contributed to the SEBs' crisis: industrial plants had accounted for two thirds of SEB-billed electricity in the 1960s; but by 1991, this share had fallen to 40 per cent (Dubash 2001). The electricity sector's debts amount to around 1.5 per cent of India's gross domestic product (GDP) (Lal 2006). Electricity shortfalls of 7.3 per cent are estimated, and blackouts and brownouts (a drop in voltage that causes lights to dim) are endemic (Planning Commission 2006a).

There were a number of attempts to restructure the electricity sector at state level in the 1990s. These reforms led to the 2003 Electricity Act, which seeks to overhaul the electricity sector across India. This report particularly focuses on whether restructuring the electricity sector can supply additional renewable power through decentralised networks and also improve energy efficiency.[7]

Increasing renewable power provision

Approximately US$14 billion of investment will be necessary to ensure that India meets its target of providing 10 per cent of power from renewable sources during the 11th plan, 2007–2012 (MNES 2006). Recent policies have the potential to help deliver renewable power. The 2003 Electricity Act mandates that newly-created State Electricity Regulatory Commissions (SERCs) fix a minimum percentage of power procurement from renewable energy. Already, around half of India's states have set, or are in the process of setting, renewable power obligations. SERCs have also provided preferential tariffs and energy transmission regulations for renewable power generators (see Table 3.1).

Central government also provides financial and fiscal incentives to the renewables sector. The MNES has recently proposed that renewable power generators enjoy a 10-year corporate tax holiday, and concessional tariffs on excise duty and the import of capital equipment. The India Renewable Energy Development Agency also provides concessional loans and banking facilities.

International donors have played a significant role in electricity sector reform. The World Bank committed US$9.3 billion to power sector investment in India and China between 1990 and 2005 (World Bank 2006). The UK Government provided US$110 million of technical assistance to the Orissa Power Restructuring Project and US$93 million towards reforms in Andhra Pradesh in the 1990s

Table 3.1: Renewable power provision obligations for wind energy projects* set by selected Indian states in 2003

State	Status of regulation	Quantum	Preferential wind energy tariff (rupees/kwh)
Madya Pradesh	Final regulation	0.5%	3.97
Maharashtra	Order issued	750 MW	3.50
Karnataka	Final regulation	5-10%	3.40
Orissa	Final regulation	3%	-
Gujarat	Draft regulation	5%	-
Tamil Nadu	Draft regulation	-	-
Andra Pradesh	Discussion paper	5%	3.42

Note: *Biomass, hydro power and other renewables would have separate preferential tariff arrangements
Source: Shah 2005: 9

7. The restructuring of the electricity sector has been extremely controversial because it has sometimes been synonymous with privatisation. This report does not discuss, per se, the broad principles behind the reforms that that have transformed vertically integrated, public corporations into separate generation, transmission and distribution utilities that have been partially privatised. Dubash 2002a provides a full account of these reforms.

and early 2000s (Action Aid 2004, Sreekumar 2002).

However, the development of renewable power has only received minimal support from the international community. Large-scale fossil fuel projects have received the lion's share of support. The recent Extractive Industry Review noted that the World Bank's support for fossil fuel projects accounted for 94 per cent of its energy investment portfolio (Hampton 2005). Export Credit Agencies (ECA) in developed countries also play a crucial role, providing government-backed loans, guarantee and insurance for investors who conduct business abroad. Yet from 2000 to 2003, support to renewable energy projects was less than 1 per cent of total support by most ECAs (UNEP-SEFI 2004).

It is important that priorities are rebalanced. These institutions should phase out investments in fossil fuels, take on aggressive targets to promote the funding of renewable projects, and adjust the rules that discourage investments in low-carbon technologies (Hampton 2005).

Furthermore, there are concerns within India that the wholesale liberalisation of the power sector, which was promoted by international donors, did not always lead to improved social and environmental outcomes in the 1990s. Opening the market to independent power producers in the early 1990s did lead to a number of renewables generation plants being developed by MNES and the Global Environmental Facility (GEF). However, this first round of reforms also led to many states locking themselves into financially disadvantageous, long-term power purchase agreements to buy electricity from international companies, who often used dirty power generation technologies (Dubash 2001). And the Indian government will need to actively plan the expansion of power provision and subsidise the renewables sector if it is to achieve universal access to clean sources of power – an ambition that sits uncomfortably with the rhetoric of liberalisation (Planning Commissiona 2006, Dubash 2002a).

Improving the energy efficiency of electricity users

The Indian government's Accelerated Power Development and Reform Programme could bring consumer energy savings in the power sector that are both cost-effective and environmentally beneficial. However, the reform process has been stymied. In 2002, the national government set targets for reducing Aggregate Technical and Commercial (AT&C) losses – a euphemism for unbilled, often stolen, electricity – from 40 per cent to 15 per cent by 2005. However, losses still stood at 40 per cent in 2005 (Planning Commission 2006a).

Quite clearly, if electricity were properly metered and billed, the SEBs' financial position would improve, as might energy efficiency. Tariff reforms, however, are a politically sensitive subject. In 2004, for instance, the newly elected Chief Minister of drought-hit Andhra Pradesh reversed his predecessor's tentative reforms and reintroduced free power provision to farmers, having made these promises the centrepiece of his election campaign (Lal 2006).[8]

There is also a difficult question over how the international donors' priorities of financial discipline and cost recovery fit with the Indian government's goal of achieving universal electrification. Research suggests that around 50 per cent of Indian households would not be able to pay for electricity if domestic tariffs were set at commercial prices. Providing electricity generated from renewables could impose even greater costs on consumers, making AT&C losses an even more fraught issue.

While acknowledging that current policies are 'poorly targeted and result in serious price distortions and malpractices' (Planning Commission 2006a: 79–80), the Indian Planning Commission has recently argued that the state should still provide subsidies that benefit the weaker sections of society and attain environmental objectives. It is important for IFI programmes in India to reflect these priorities, and help the Indian government to devise transparent policies and subsidises to provide clean, cheap electricity to the millions of households who lack this basic need.

Coal

Today, coal accounts for around half of India's commercial energy supply and 70 per cent of electricity generation (Sarma 2006). However, the Indian coal sector is facing a crisis. Coal reserves may be much smaller than expected, and a complex web of subsidies and price controls favours the inefficient use of dirty coal (see Box 3.0). This crisis in the coal industry opens up opportunities to introduce reforms to the power sector: removing wasteful subsidies that prop up inefficient practices in the sector, diversifying sources of energy supply, and also encouraging the entry of more independent power producers in a more decentralised system of energy provision. However, the reality is that centralised, coal-powered electricity provision will be an integral part of India's energy mix for decades to come. Indeed, it is commonly agreed that some parts of India's current centralised system of energy provision, such as the National Thermal Power Corporation, the sixth largest thermal power generation company in the world, are run very efficiently (Dubash 2001).

The Indian government unambiguously notes that coal will continue to play a primary role in meeting Indian energy needs during the next decades. Even the Planning Commission's most radical energy supply projections, which assume a 44-fold expansion of renewable power provision, suggest that India will require 632 Mtoe coal in 2031/2, some 40 per cent of total supply (Planning Commission 2006a). The Indian coal industry also has a formidable political presence, being the second largest private employer in the world after the Ford motor company (Batra 2004).

The dramatic challenges facing India's coal sector are faced elsewhere in the world. IEA figures suggest that coal accounts for 9,023 million tonnes of global CO_2 emissions per annum, nearly 40 per cent of total energy emissions. Coal emissions are projected to grow worldwide by 55 per cent from 2002–2030 (IEA 2004b).

The notion of 'cleaner coal' has been an anathema to many green groups in the West. Whereas renewable power provision offers the hope of bringing power to the people through decentralised energy

8. There is a difficult debate over whether farmers could and should pay more for their electricity; and whether, by paying higher rates, farmers might actually make overall cost savings, because they would receive a more secure supply of electricity (Lal 2006, Dubash 2001).

Box 3.0: India's coal sector: crisis and opportunity

How much is left?

Open-cast mining has been favoured over underground mining for many years, a practice that produces low-grade coal, with low thermal efficiency. Although the Geological Survey of India has long given the impression that coal reserves would last for a couple of centuries at the current level of consumption, other institutions' research suggests that less than 20 per cent of total geological resources might be actually extractable (Chand and Sarkar 2006). The coal locked in the ground is often in inaccessible areas – below towns, under forest reserves and so on – and studies suggest it will only be removable using integrated gasification combined cycle (IGCC) technologies that gasify the coal underground. However, IGCC plants could be more energy efficient than current power plants. IGCC can also be relatively easily adapted to be used together with CCS technologies.

Reforming subsidies and prices

India's coal is also often low grade and thermally inefficient. This is the result of a complex web of subsidies, fixed prices and long-term purchasing contracts that govern the extraction and transportation of coal. In the mid 1990s, some studies estimated that these price distortions might increase the cost of coal for the consumer by a factor of three (Bhansal and Abaye 1995). Reforms have been made since then, but many pernicious practices remain.

The Indian Planning Commission has strongly recommended that prices are rationalised so that there is a closer correlation between the cost of coal and its thermal efficiency. This measure would improve fuel efficiency and energy conservation (Planning Commission 2006a, Dubash and Bradley 2005). Furthermore, due to these reforms, coal washeries, which would remove some of this ash, are slowly being developed and imports of higher-grade coal are gradually increasing (Batra 2004).

provision, investing in new coal technologies will perpetuate centralised power systems. Furthermore, clean coal technologies are unproven and costly, and may divert capital away from investments in renewable energy.

However, there is an urgent need in India, as elsewhere in the world, to develop and deploy clean coal and near-zero emissions technologies. India is planning an extensive investment programme to meet its energy supply crisis. The gap between the supply and demand of coal stood at 44 Mt in 2006/7 and is projected to grow to 95 Mt by 2011/2 (Sarma 2006). The Ministry of Power intends to build coal plants with a total capacity of 24,100 MW during the 11th and 12th plans (Kumaran 2006). These intentions are echoed in the Indian government's plan to build around seven 4,000 MW 'ultra mega' thermal power plants, each of which will burn around 12 Mt of coal per year (*The Hindu*, 12 December 2006).

India's extensive building programme may lead to opportunities to invest in cleaner coal technologies. A number of options are possible. First, there are opportunities to make emissions savings with commonly used technologies. A typical 500 MW plant could reduce CO_2 emissions by 40,000 tonnes per annum through energy efficiency improvements. Second, commercially available Ultra Super Critical and Advanced Super Critical plants may offer thermal efficiencies of 45 per cent, possibly more. Currently, conventional pulverised coal combustion plants, which account for the majority of India's coal power plants, only have a thermal efficiency of around 35 per cent (Shahi 2003). Third, a handful of coal power plants around the world use IGCC technologies. These are at least as efficient as Super Critical technologies, and could possibly be 10 per cent more efficient (Shahi 2003, Ockwell *et al* 2006). Fourth, there are a range of available CCS technologies that have near-zero emissions that are at demonstration stage. Currently, it seems that CCS systems fitted onto IGCC plants have the greatest potential (Mundy 2006). However, IGCC is an emerging technology: it has high capital costs, and lacks a reliable operational history in India; indeed there are only five 'utility-scale' demonstration plants in the world (Ockwell *et al* 2006). CCS is even less developed.

A number of demonstration projects could advance the development of cleaner coal and zero-emissions technologies in India. India is in the middle of constructing a demonstration 100/125 MW coal-based IGCC plant at a cost of around 7 billion Rupees (approximately £86 million, at current conversion rates). Most of the additional finance for this project, which is more expensive than a normal coal power plant, comes from the US (Kumaran 2006). India has responded more cautiously to UK proposals to develop a demonstration CCS plant on Indian soil. Prime Minister Singh has given some indications that cooperation on this issue will be taken forward. However, at the time of writing, the Ministry of Power was unwilling to test this technology, which consumes more energy per unit of power output than conventional technology, at a moment when power investment needs are pressing. The Indian government has also argued that CCS technology should not be eligible for CDM credits, which would subsidise its costs. By contrast, the UK and Chinese Governments have established a partnership to bring forward CCS technology in China.

The UK and EU have yet to develop a comprehensive clean coal policy that would provide regulatory and financial support to this crucial part of the energy sector in developing countries. Development of such policies has to be made an urgent priority given that coal-fired power stations, which will operate for decades, are being built at a rapid rate in India, meaning that carbon emissions are set to continue at an increased rate for many years to come.

It is difficult to detail a balanced comprehensive cleaner coal policy when 'the emerging status of [CCS] technologies means there is still uncertainty about its development and economic feasibility' (HM Treasury 2006b: 2). Optimistic estimates suggest that the large-scale uptake of CCS technologies is around ten years away (IEA 2004b). It is also important that fiscal regimes and subsidies do not support CCS at the expense of renewables.

However, the broad dimensions of a carefully modulated clean coal policy can be sketched out. First, assuming that CCS technology

Table 3.2: Cost to produce electricity using various technologies

Technology	Cost in 2000 (p/kWh)*	Cost in 2020 (p/kWh)*
Gas	2.2-2.4	2.1-2.2
Coal	3.6-3.9	-
CCS for gas	3.5-3.7	3.0-3.2
CCS for coal	5.7-6.1	4.5-4.9

Source: HM Treasury 2006b: 10
Note: p/kWh = pence per kilowatt hour

proved viable, the West would have to be ready to mobilise capital to support the additional costs of CCS, which is likely to be more expensive than other energy supply options for a number of years to come (see Table 3.2). Indicative figures suggest that €2 billion of investment per annum for five years would produce 4–10 GW of clean coal investment per annum, which would lead to CO_2 savings of 600–1,400 $MtCO_2$ over the lifetime of the coal-fired plants (Mundy 2006). Such funds could be raised in a variety of ways: through auctioning emissions trading permits, or diverting environmental taxes to a clean coal fund, and governments and IFIs could also make direct investments.

Second, OECD countries should play a leadership role in piloting these technologies. Given that nearly all coal-fired plants in OECD countries are scheduled to be decommissioned by 2030, any new plants should be built 'capture ready' as it is very costly to retrofit CCS facilities onto a power plant (World Bank 2006). Capture readiness should become a regulatory requirement under the European Integrated Pollution Prevention and Control regulations. It is problematic for Western donors to press this agenda in India and elsewhere unless the West is taking action itself.

Improving end-use efficiency in industry and the domestic sector

India's energy intensity per unit of GDP does not match best practice but is improving (see Table 3.3). The Indian Planning Commission also emphasises that India's energy efficiency performance is comparable with that of many other countries if poverty and thus inability to allocate capital to energy efficiency projects are taken into account. However, there are numerous opportunities to improve energy efficiency savings, which would bring substantial economic benefits (Planning Commission 2006a). Estimates suggest that 25 per cent savings are possible in industry, and 25–50 per cent in the commercial sector (BEE 2006).

The picture varies from sector to sector. The energy-intensive industries that trade with the rest of the world – such as steel, fertiliser and cement – are the most energy-efficient of all. The newest industrial plants in these sectors use the best available, most energy-efficient technology, comparable with anywhere in the world. However, there is a 'long tail' of older, inefficient manufacturing plants that can survive in competitive global markets: the extra costs of debt maintenance for the newer plants offset the lower running costs of these more efficient, new plants. Thus the older plants drag down the average performance of India's energy-intensive industries (see Table 3.3). However, these old, run-down plants will be replaced in due course by new plants that use the best available technology.

Energy-intensive small and medium enterprises (SMEs) – industries such as foundries, steel rolling mills and textiles factories – are much less energy efficient, however. This is a surprisingly large sector: in terms of value added, these enterprises might account for a quarter to half of the industrial sector. For instance, 75 per cent of New York's manhole covers were made in India (Gupta 2006). The challenge here is to develop and distribute energy-efficient technologies to SMEs.

A number of projects focus on this sector, and some funding is provided by international donors. For instance the Energy Research Institute has successfully promoted the use of an energy-efficient foundry furnace. However, there is a significant opportunity to dramatically expand the provision of and mandate the use of energy-efficient products (Mathur 2006).

In addition to measures to improve the energy efficiency of industry, there are opportunities to reduce energy demand in the commercial and residential sectors through improvements in building design and changes to user behaviour. For instance, the Indian government is improving its enforcement of building codes and standards, and developing energy-efficient product standards and labelling (Planning Commission 2006a).

In recent years India has taken important steps towards improving the public policy frameworks that encourage energy efficiency. The 2001 Energy Conservation Act provides for a raft of regulatory

Table 3.3: Efficiency of energy-intensive industries

Sector	Units	Average consumption, 1991	Average consumption, 1995	Best technology, 2000
Cement	Kwh/tonne	132	120.5	69
Paper	Mwh/tonne	1.26	1.00	0.99
Caustic soda	Kwh/tonne	3351	3130	2196
Aluminium	Kwh/tonne	16,763	16,606	15,217
Steel	G.Cal/tonne	11.27	8.93	7.48

Source: Chandler *et al* 2002: 6
Note: Kwh: kilowatt hour; Mwh: megawatt hour; G.Cal: giga calorie ('giga' means 'one billion')

powers and tasks a newly created Bureau of Energy Efficiency with enforcing laws and developing new programmes. However, the Bureau has been understaffed, employing only five officers in 2005 (Planning Commission 2006a). States also have the opportunity to set up designated energy efficiency agencies. Not all have done so, but those that have taken the best approach, such as Orissa and Punjab, have implemented demand-side management programmes and require all government buildings to use energy-efficient lighting and solar thermal heaters (Mathur 2006).

There is a great opportunity for the international community to support the Indian government and business in their efforts to improve energy efficiency. Although energy efficiency projects often bring net savings, the private sector and government in India often lack the capital to make investments into what is considered to be not a core activity. Thus energy service organisations are inadequately funded. A recent report from the International Energy Agency suggested 'this could be an area requiring finance from [international] financial organisations' (Williamson 2006: 25).

Also, financial instruments should better support energy efficiency initiatives. For instance, IFIs too often neglect energy efficiency opportunities – although there are notable exceptions. Likewise, energy efficiency only accounts for 3 per cent of the CDM credits (see Figure 4.1). A recent report concluded that, while Indian coal plants could make huge efficiency improvements, the Indian project developers had not attempted to partially offset capital costs by tapping into these CDM financial flows (Ockwell *et al* 2006).

Reducing pollution from transport

Because of poverty, India's use of transport is low by global levels. Out of the 600,000 villages in India, only 60 per cent were connected by all-weather roads in 2002. More than 45 per cent of villages with fewer than 1,000 people have yet to be connected by road. Car ownership in cities of more than 100,000 stands at only 102 per 1,000 people (and the national average will be much lower). Sixty to 80 per cent of journeys within cities are made by public transport (Planning Commission 2002a, 2002b). By contrast, in 2003 44 per cent of UK households had one car, 25 per cent had two, and 5 per cent three, and only 8 per cent of journeys are made by public transport (DfT 2005).

Emissions from the transport sector are expected to grow exponentially in the coming decades. Energy consumption in the transport sector is estimated to increase by 14 times from 34 Mtoe in 2001 to 461 Mtoe in 2031 (TERI 2004). Much of the increase in vehicle miles travelled will be due to increased numbers of people having higher levels of disposable income. Nevertheless, India is also experiencing a shift in people's transport use, with journeys increasingly being taken using private modes. The relative share of railway journeys has declined dramatically since 2002: from 90 to 25 per cent for inland freight journeys, and 78 to 18 per cent for inland passengers (Planning Commission 2002b). India's use of public transport also compares poorly with China's. China moves freight along its rail tracks 5.5 times more efficiently than India (Planning Commission 2002a).

India's aviation sector has also grown rapidly from a very low base in recent years, with passenger traffic increasing at 25 per cent per annum (Blakey 2007). For instance, between Delhi and Mumbai, more people travel by air than by all classes of rail transport (Planning Commission 2002c: 51). The number of airports has increased from 84 in 1980–81 to 122 in 1999–2000 (ibid). Nevertheless, the aviation sector is still very small. The vast majority of freight is handled by road and rail transport.

Improving 'economic efficiency, environment conservation and social impact' is one of the key objectives of India's transport policy (Planning Commission 2002a: 4). The consequences of unplanned, burgeoning growth are well documented. The transport sector consumes 40 per cent of energy and a substantial proportion of imported diesel and petrol supplies – at a time when energy supply and security issues are at the forefront of concern for the Indian government. Congestion stymies economic growth and reduces productivity. It is estimated that the average productivity of a truck is 200 km per day, but 350–400 km would be possible if congestion were improved (Planning Commission 2002a). Congestion also causes health problems, particularly in cities. In Kolkota, for instance, nitrous oxide and particulate pollution is well above legally permissible levels (Planning Commission 2006a).

The Indian government is taking forward a number of overlapping policies in the road and rail sectors that could significantly reduce emissions levels against business-as-usual projections. Notably, the 2002 Integrated Transport Policy argues that the proportion of freight using rail transport should return to previous levels through a combination of expanding railway capacity, correcting pricing policies, and driving through organisational change. India's 2003 Auto Fuel Policy sets out a timetable for new vehicles to meet improved emissions standards (Ockwell *et al* 2006). This might reduce hydrocarbon and nitrous oxide emissions by 20–30 per cent; reductions of these emissions often lead to a commensurate reduction in greenhouse gas emissions.

Biofuels may be used increasingly in transportation. In 2002, the Government of India issued a notification declaring it mandatory to use a 5 per cent ethanol blend in petrol in nine states and four union territories, beginning 1 January 2003, but this was not implemented, largely because energy crops were fetching high prices in other markets. However, in the current climate of high oil prices, there is renewed interest in this policy. Since 2006, public sector oil marketing companies have been purchasing biodiesel at a concessionary rate of Rs 25 per litre. There are also various projects being undertaken by both national and state level government to support the development of energy crops (Devraj 2006, Sandenburgh and Singh 2006).

Policies are also being developed at city level. In Delhi, an underground metro and rapid transit bus services are being developed. Vision 2020 argues that electric trolley buses, rapid transit bus routes and rail-based mass transport systems 'appear to be the only viable solution to the problems of urban transport in India's major metropolitan areas' (Planning Commission 2006b: 65). In addition, a number of cities have mandated that public transport use low-carbon fuels. Most notably the Indian Supreme Court ruled in 2001 that Delhi buses, taxis and auto-rickshaws should use Compressed Natural Gas fuel.

One study estimates that these combined measures could reduce transport's CO_2 emissions by 15 per cent from a business-as-usual

Table 3.4: Target year for meeting European light vehicle emissions standard equivalents in India, China and Europe

European standard	I	II	III	IV
India	-	2005	2010	-
China	-	-	2007	2010
Europe	1992	1996	2000	2005

Source: Ockwell *et al* 2006: 105

scenario (CCAP 2006). Nevertheless, these reductions will not be achieved unless the international community provides support that enables the Indian government to overcome the additional financial costs of promoting low-carbon and energy-efficient measures, to understand the real and perceived technology risks, and to get to grips with the vagaries of the carbon market. For instance, numerous biofuel projects in India are eligible to receive credits under the CDM but they need support to do so: the CDM has not facilitated financial transfers to the large public railway sector, for example, a sector that has the potential to deliver large emissions reductions. In part this is because current CDM rules, which do not easily allow projects to calculate emissions savings across entire industrial sectors, make it difficult to agree the carbon savings that would be made by such projects and thus the number of CDM credits they should receive. Also, the Indian government has lacked capacity to develop CDM railway projects (Gonsalves 2006).

The next section outlines the elements of emerging international policy mechanisms that could help India to implement appropriate polices to reduce its carbon footprint.

4. International policies to support emissions reductions in India

Ultimately, India will only hold back greenhouse gas emissions to acceptable levels if the international community provides adequate assistance and support. The first parts of this section discuss three means by which India could make these reductions:

- By taking on appropriate emissions targets in the context of equitable international climate change agreements based on common but differentiated responsibilities in which developed countries take on stringent emissions reductions of their own and also provide low-carbon technologies to developing countries (Globe 2007, G8 2005).
- By earning credits that are bought by industries and countries in the developed world – with developed countries, in effect, paying to reduce Indian emissions.
- By having its emissions paid for by the developed world through non-credit policy mechanisms.

This section also discusses the importance of developing policies to ensure that India has access to low-carbon technologies without Intellectual Property Rights getting in the way.

Making deeper emissions reductions in industrialised countries

Before further actions from developing countries can be discussed, the industrialised countries that fall under Annex I of the UNFCCC will have to make greater efforts to reduce their own emissions.

The UK has an important role to play in encouraging the European Union to make further emissions reductions and it has performed quite well compared with most other EU countries. Although off track on its national commitments to cut CO_2 by 20 per cent below 1990 levels by 2010, the UK will comfortably meet its Kyoto target of reducing greenhouse gases by 12.5 per cent.

The EU is seeking to take a leadership position on emissions reduction. But despite its Kyoto Protocol commitments to reduce its emissions by 8 per cent from 1990 levels by 2012, the EU is only on track to make a reduction of around 1 per cent, through domestic policies and measures (EEA 2006). Individual member states have been slow to use the innovative European Union Emissions Trading Scheme (EU ETS) to reduce their industries' emissions. The preliminary phase of the scheme (2005–7) is unlikely to have led to emissions reductions, and the European Commission has had to reject member states' plans for the second phase of trading (2008–2012) because their proposed emissions cuts were not ambitious enough (EC 2006).

The EU has also drafted a policy that would commit it to making emissions reductions of between 20 and 30 per cent by 2020 (EU 2007). ippr research suggests that this higher emissions reductions target could – just – be enough to avert dangerous climate change (Baer 2006).

Persuading developing countries to take further action will also be much easier when the industrial countries that did not ratify the Kyoto Protocol return to the negotiating table. The position of the US, in particular, is crucial because that country emits around a quarter of the world's greenhouse gases. While the current administration has been reluctant to take on climate commitments, it is likely that future presidents, whether Republican or Democrat, will undertake binding emissions reductions targets. Already, American states and cities are developing programmes to achieve quantified emissions reductions. And there are a number of bipartisan proposals before the US Congress that propose ambitious, nationwide emissions cuts.

Furthermore, the international community has taken the first tentative steps towards negotiating a successor treaty to the Kyoto Protocol. At the 2007 G8 summit, all G8 leaders – including the US – agreed that the UN climate process is the appropriate forum for negotiating future action on climate change, and that all major emitting countries would have to come to a global agreement by 2009. The EU, Canada and Japan have resolved to at least halve emissions from 1990 levels by 2050.

These developments could bring new vigour to international discussions on how developed and developing countries can together take action to reduce emissions. This was seen in the February 2007 Washington meeting of Global Legislators Organisation for a Balanced Environment, a forum that contains the G8 and +5 countries. At the meeting, the legislators agreed a statement that stated that GHG emissions should be stabilised at between 450-550 ppm of CO_2e. Elements of an agreement to achieve this goal would include, among other things, 'long term targets for developed countries… [and] appropriate targets for developing economies' (Globe 2007: 2).

Appropriate emission-reduction goals for India

As discussed above, India will need to make quantified emissions reductions against business-as-usual expectations, if GHG concentrations are to be brought to levels at which dangerous climate change is avoided. This is likely to be costly: one study has found that only 12 per cent of India's emissions reductions would be cost-free or make savings (CCAP 2006). It is likely that the developed world will pay for much of India's emissions reductions efforts; indeed, it is appropriate that this should be so, given India's poverty and that climate change is a crisis caused largely by the developed world. Nevertheless, India should take on some of the emissions reduction burden.

It is not the place of this report to recommend precisely how this balance of effort should be shared between India and developing countries. Furthermore, the Government of India has consistently argued against taking on binding commitments. 'There have been suggestions recently that a process should commence to enhance commitments of developing countries on mitigating climate change… This suggestion is misplaced,' the Prime Minister noted in 2002 (Vajpayee 2002). The Government's rhetoric was little changed in 2006 (IISD 2006).

Nevertheless, emissions reductions targets could become politically acceptable for developing countries, given the appropriate context. In the late 1990s, the Indian government advocated that countries' emissions entitlements should be decided on a per-capita basis according to the contraction and convergence model. Previous ippr reports have advocated a multistage approach to sharing the emissions reduction burden, which allows countries at different stages of economic development to take on different emissions reductions commitments (ippr 2005b). Figure 1.0 in this report shows that both such methods of sharing the emissions reduction burden could provide India with room for economic growth, as long as it were given appropriate support to move towards a low-carbon path of development.

Future global agreements could also recognise that India is already in the process of decarbonising its economy, thus making emissions savings, often at cost to itself. The energy intensity of India's economy improved in the 1990s, saving around 111 $MtCO_2$ against business-as-usual projections. This trend is likely to continue in the next decades, leading to further carbon savings. Furthermore, the Indian government and consumers have paid for the costs of much of the emissions reductions. One study has estimated that 30 per cent of India's emissions reductions are not paid for by developed countries through the Clean Development Mechanism (CCAP 2006).

Credited action against climate change

The second means of achieving quantified emissions reductions is for Indian emissions reductions to earn credits that are bought by industries and countries in the developed world. In effect, developed countries would pay to reduce Indian emissions through this policy mechanism.

Indeed, the Clean Development Mechanism (CDM) established by the UNFCCC was designed to do this task, so that carbon markets can support sustainable development projects in developing countries. The Kyoto Protocol establishes that CDM projects in developing countries that reduce emissions below business-as-usual projections earn an Emissions Reduction Unit (ERU) for each tCO_2e that is saved. Annex I countries can buy these ERUs to meet their Kyoto emissions reductions targets. Similarly, installations included in the EU ETS can also buy these ERU credits in place of making emissions reductions themselves. The CDM market was worth Eur 2 billion in 2005 (Point Carbon 2006).

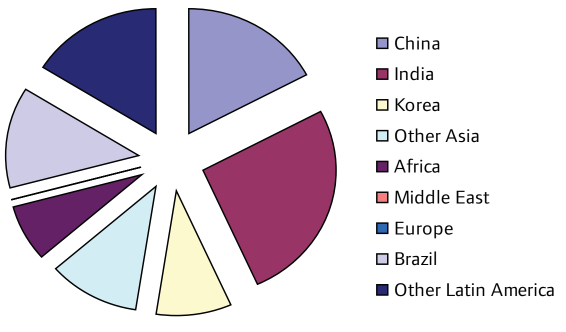
India has done well, relatively speaking, from the CDM (see Figure 4.0). In 2005 it generated 27 per cent of CDM emissions credits – a share of the market that was proportionately much larger than India's share of the global economy (Ellis and Levina 2005).

Nevertheless, a critique can be made of the current design of CDM policy. The question continually asked of the policy concerns the extent to which it supports low-carbon, sustainable development. The CDM rewards isolated, individual projects that rarely have transformational effects and produce few emissions reductions (Figueres 2006). Furthermore, the CDM does not generate significant new amounts of low-carbon investment. One reason is that only a minority of investments are made in expensive renewables and low-carbon energy projects because it is cheaper to invest in low-cost projects that reduce F-Gas (fluorinated greenhouse gases) and nitrous oxide (N_20) emissions (see Figure 4.1). Indeed, it is likely that many of these projects that reduce F-Gas and N_20 emissions would have been undertaken even without CDM funding.

In one sense it can be argued that it does not matter whether the CDM delivers more renewable electricity generation, or delivers F-gas reductions: all GHG emissions reductions have equal environmental value. Nevertheless, the CDM had originally been seen as a policy that would deliver low-carbon development. Indeed, this is the primary challenge faced by India and other developing countries whose economies are growing rapidly. Thus, figures produced by the Indian government suggest that the low cost of CDM credits means that this policy mechanism might only offset 1–5 per cent of the capital costs of an investment in a wind farm (MNES 2006, Shah 2006). In addition, many CDM projects in India have been hurriedly developed by foreign consortiums, sometimes at the expense of local communities (CSE 2006b). In short, CDM may help reduce emissions worldwide (against business-as-usual expectations), but it has not helped India's sustainable development.

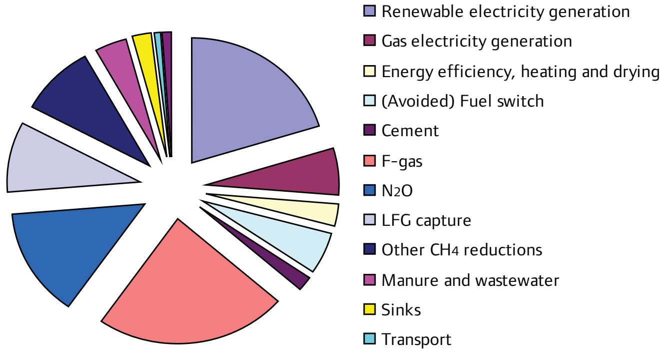
One option to improve this situation would be to develop 'programmatic' or 'sectoral' CDM that credited emissions reductions efforts made across a sector of an economy at a regional or national level. UN climate policy rules could be revised in this direction to a certain extent. Also, multilateral development agencies and the Indian national government are beginning to develop a form of

Figure 4.0: Geographical split of expected annual CDM credits, November 2005



Source: Ellis and Levina 2005: 11

Figure 4.1: Percentage of annual credits, worldwide, by project type, November 2005



Source: Ellis and Levina 2005: 8

programmatic CDM by 'bundling together' individual CDM projects. This approach could be further developed by establishing emissions baselines in key sectors of the economy. Emissions reductions against these baselines would generate credits (CCAP 2006).

An alternative to programmatic or sectoral CDM would be to develop a broadened-out Sustainable Development Policies and Measures (SDPAM) framework. Developing countries would undertake policies that are primarily focused on their sustainable development, with climate change mitigation measures considered as a co-benefit that can be credited. Countries would examine how development priorities can be achieved in a more sustainable manner, then pledge these policies and measures in a registry maintained by the UNFCCC secretariat (Winkler 2006).

Programmatic CDM and SDPAMs could evolve into sector-wide targets for the major sectors of the Indian economy. Indeed, similar policies were mooted at the 2006 UNFCCC conference. A consortium of countries led by Brazil made a proposal to establish voluntary deforestation targets. A baseline would be defined using historic data, countries would implement policies and measures that reduced deforestation, and then be credited for achievements made against this baseline (Brazil Government 2006).

Establishing no-lose targets for major industrial sectors that were competitive in the international economy might serve the interests of both India and developed countries. As the previous sections have noted, the major source of India's emissions growth will come from the electricity and transport sectors, as households become wealthier. India's competitive industries, such as aluminium and steel production, do not account for the majority of India's GHG emissions. While Indian industries often use the best available, most energy-efficient technologies, and so could fare well under energy intensity commitments, energy intensity targets in these sectors could assuage Western industry concerns.

The EU could also encourage low-carbon sustainable development projects by placing restrictions on the type of CDM credits that are bought into the EU ETS. Already, the EU has placed some restrictions on the credits that can be used. For example, hydropower project ERU credits are only accepted if the project has complied with the recommendations made by the World Commission on Dams (EU 2004: Article 14). It would be possible to have tighter regulations still. For instance, a number of businesses only offset their emissions with 'Gold Standard' CDM credits that meet stringent low-carbon, sustainable development criteria.[9] An alternative would be for the EU ETS to forbid the use of ERU credits generated by F-Gas and N_2O emissions reductions projects.

Another major problem with current CDM policy is that, in several senses, it does not lead to additional emissions reductions. Developed countries can buy CDM emissions credits from developing countries instead of making emissions reductions at home. This CDM transaction process has severe limitations. A credit a developed country earns through reducing emissions at home is not equivalent to a CDM credit that only avoids emissions – that is, brings emissions below business-as-usual growth rates. When a developed country buys a CDM credit rather than making absolute emissions reductions at home, global emissions levels are not being lowered, just stalled.

Furthermore, demand for CDM investment will only be driven by industrialised countries taking on deeper emissions reductions targets, but meeting their targets by investing in emissions reductions in developing countries. This is a double-edged policy. On the one hand, extra investment into the CDM will assist low-carbon development and emissions reductions in India. Nevertheless, it is also important that financial aid given to developing countries to help them fight climate change must be additional to other international aid and commitments. Nor can the finances given by CDM simply be seen as development aid when these monies have been disbursed in place of developed countries making emissions reductions at home (G8 2005).

Providing further financial aid to India

The third means of achieving quantified emissions reductions in India is through developed countries paying for Indian emissions reductions through policy mechanisms that are not credited.

Historically, International Financial Institutions (IFIs) have played a significant role in supporting energy sector investments in developing countries. In 2004, 37 per cent of World Bank investments, worth US$7.6 billion, were made in the transport, oil, gas, electric power or mining sectors: the Inter-American Development Bank invested US$730 million, 12 per cent of its total investments, in these sectors, and the European Bank for Reconstruction and Development provided £3.3 billion of support, some 27 per cent of total lending (Sohn *et al* 2005). The role of IFIs is likely to expand in coming years: achieving universal electrification in India by 2030 will require investments of US$130 billion according to World Bank estimates (World Bank 2006). Ensuring that this investment is clean as well as cheap will cost even more.

So far, the international response to this challenge has been inadequate, first, in terms of financial flows. The Global Environmental Facility (GEF), the largest source of multilateral financing for low-carbon technologies, was replenished in 2006 with US$3.13 billion to spend from 2006–2010 (GEF 2006). Nevertheless, a World Bank Energy Investment Framework review suggests that funding would have to be increased by a factor of ten to achieve sustained market penetration of pre-commercial energy efficiency and renewable energy technologies (World Bank 2006). These funding commitments to decarbonise the economy will have to be additional to the financial support that is necessary to help India and other developing countries adapt to the impacts of climate change (see Box 4.1).

Second, climate change considerations are rarely mainstreamed into loans given by multilateral banks. More than 80 per cent of the World Bank's disclosed lending from 2000 to 2004 did not consider climate change issues in project appraisals and documentation (Sohn *et al* 2005). There are, however, examples from elsewhere of how low-carbon lending could make significant carbon savings (see Box 4.2). Multilateral institutions should take on aggressive targets that promote the funding of energy efficiency and renewable projects.

9. See www.cdmgoldstandard.org/. Gold standard CDM credits come from renewable energy or energy efficiency projects

Box 4.1. Adapting to the impacts of climate change

While it is widely recognised that India will have to adapt to climate change, much remains uncertain. The joint UK-India study on the impacts of climate change on the subcontinent will greatly extend policymakers' knowledge base of the challenges faced (UK-India 2005) – particularly after a proposed second phase that will look at impacts at state level. What is clear is that the policy challenges are immense.

First, there is a need to understand how the likely consequences of climate change will interact with other social and economic issues (ISET-WII 2006). Climate change processes are occurring in parallel with fundamental changes in social, economic and technological systems. (For instance, southern Africa was hit by drought in the late 1990s, at the same time that many adults were severely affected by the HIV/AIDS epidemic, thus making rural households doubly vulnerable.)

Second, climate change considerations will have to be mainstreamed into overseas development aid (ODA) programmes. Because many of the consequences of climate change – such as drought and floods – are already major challenges for the subcontinent, the Indian government and international donors have existing programmes that address these issues, which can be scaled up.

The UK Government's White Paper on International Development (Department for International Development [DFID] 2006) is expected to greatly assist the process of mainstreaming adaptation concerns into DFID's work in India. However, only 2 per cent of World Bank projects even mention climate change in project planning (World Bank 2006).

Third, additional funding is required. Conservative estimates suggest additional adaptation costs might add 5–20 per cent to climate-sensitive ODA; the experience of the Global Environment Facility (GEF) suggests 20 per cent might be the minimum default value. The current global ODA and lending portfolio is approximately US$100 billion per annum (World Bank 2006).

Currently, less than 1 per cent of concessional lending and ODA is directed specifically towards adaptation. There is now an Adaptation Fund, resourced by a 2 per cent tax on most CDM transactions. This is an additional source of funding, but will only provide a total of US$100-500 million up to 2012. Donors also make contributions to the GEF, which has two trust funds for adaptation. These finances provide approximately US$150–300 million per annum in total, ten times less than what is needed (World Bank 2006).

Box 4.2. Low-carbon lending for energy efficiency

The European Bank for Reconstruction and Development (EBRD), which invests in Central and Eastern Europe and Central Asia (though not India), provides an example of how it is possible to raise the profile of energy efficiency in its financing of industrial, municipal infrastructure and power sector projects.

A dedicated team examines EBRD project proposals, identifying potential energy efficiency savings. From 2002 to 2005, it financed 35 industrial projects, worth Eur 1.45 billion overall, of which €276 million was dedicated to making energy efficiency savings. These projects have made savings of 2.5 $MtCO_2$ per annum.

The EBRD intends to scale up its climate change mitigation investment to €1.5 billion over 2006–2009.

Source: Stern 2006b

Third, the challenge of providing further financial support to India is not just one of scaling-up the size of existing funds. The World Bank recently concluded that 'the real and perceived technology risks that constrain private sector activities, and carbon market uncertainties mean that current [financial] instruments are not sufficient to accelerate the transition to a low carbon economy' (World Bank 2006: xiii). One example is the inability of the European Union Emissions Trading Scheme (EU ETS) to induce power companies to make investments in renewables technologies. This is because the EU ETS only has five-year trading periods, but utility companies make power plant investment decisions that have time horizons of several decades. The lack of predictability in the emissions markets has thus constrained investments in renewable power.

It is important to develop new financial instruments and regulations that address the weakness of current low-carbon finance. A series of reviews and reports undertaken by the G8 and World Bank have made recommendations on how this might be achieved. The most recent study into a Clean Energy Investment Framework recommended the establishment of a Clean Energy Financing Vehicle, which would provide low-interest loans to:

- assist the scaling-up and commercialisation of low-carbon technologies
- bring down the extra costs of low-carbon technologies and associated infrastructure
- reduce the financial risks associated in new, yet to be proven technologies
- stimulate continuity in the carbon market.

Initial equity would be provided by developed countries. The fund might require an initial capitalisation of US$10 billion, with annual disbursements of US$2 billion. The Vehicle might be expected to generate a reasonable rate of return and in time could attract private capital (World Bank 2006).

Other reports have called for retargeting IFI subsidies and supports away from the oil and carbon industries towards new renewables industries.

However, these recommendations have often struggled to gain traction within the international community. This has largely been due to opposition from many quarters. Long established, powerful extractive industries and associated financial services sectors, which have an influential voice in developed countries, have guarded against threats to their business. There has been a similar reaction from the significant number of developing countries that gain substantial revenues from exporting oil, gas and coal. Many such countries, who are suspicious of imposing conditionality on aid flows at all, fear that reform of IFI energy lending policies could hinder their economic development and poverty alleviation efforts. They fear that the reduction in support to their carbon-intensive extractive and energy industries will not be followed by a commensurate increase in support to emerging low-carbon energy industries (Hampton 2005).

Ensuring technology transfer

Transferring low-carbon technologies from western countries to India and other rapidly developing countries is a critical challenge. It is also a difficult subject politically, because it can impact on the relative commercial standing of technology owners and on the relative economic wealth of supplier and recipient countries (Ockwell *et al* 2006).

Effective technology transfer depends, first, on the transfer of capital goods and equipment from developed to developing countries. For example, India buys energy-efficient Light Emitting Diode (LED) lamps from abroad, rather than manufacturing them at home, because of intellectual property rights (IPR) restrictions (see Box 4.3). Second, developing countries also require access to technical knowledge in order to develop their own technological capacity. It is this capacity that will facilitate the widespread absorption of low-carbon technologies in developing countries. Third, there are complex market and financial barriers that hinder the transfer of technology (Ockwell *et al* 2006). These barriers might include the lack of access to finance, limiting industrial investment, and manufacturers might also be inhibited by low consumer demand.

International partnerships will play a vital role in driving low-carbon-technology transfer. First, it is important to develop collaborative research partnerships between industrialised and developing countries that promote the research, development and demonstration of new technologies. Many low-carbon technologies are in the early stages of development and are not yet in widespread use, even in the countries where they are being developed. To drive forward technology transfer now, we need to develop novel technology transfer mechanisms, and one form could be international partnerships. Many studies note that information-sharing initiatives, such as the UNFCCC programme TT:CLEAR, have an important role to play in overcoming these barriers (Ockwell *et al* 2006, Stern 2006b).

International collaborative research and development programmes would have the benefit of transferring knowledge normally protected by intellectual property rights (see below) and technological capacity. A global research alliance should be established as a way of linking development objectives with the current, commercially-driven IPR framework (CIPR 2002, Ockwell *et al* 2006). A strong precedent for international collaboration on research and development was set by the Consultative Group on International Agricultural Research. Created in 1971, it now has

Box 4.3: Intellectual property rights issues

The case of energy-efficient lighting

Light Emitting Diode (LED) lamps are seen as one of the most efficient future lighting sources because they have a long life and low power consumption. No Indian companies do manufacture the LED electronic chips that are at the heart of the design. Only one Indian company is approved to assemble LED components into a finished product, importing key materials from abroad. This company taught itself how to assemble LED lamps, using low-tech, manual packaging processes.

A recent report (Ockwell *et al* 2006) notes that there are four key barriers that restrict the transfer of LED technology to India:

Financial: LED chip manufacturing is energy- and capital-intensive. Indian manufacturers in this sector are relatively small and unable to make these huge investments.

Intellectual property rights: LED is a highly protected technology: each manufacturing process is patented. The cost of resolving IPR issues leads Indian companies to instead import LED chips from abroad.

Market barriers: Leading LED manufacturing companies do not see a large market for these goods in India, and therefore have not considered investing in a joint venture.

Human resources: India has highly skilled engineering and electronics graduates. However, the country does not have expertise in LED technology.

The case of hybrid vehicles

Hybrid technologies, used in cars such as the Toyota Prius, can reduce vehicles' fuel consumption by between 20 and 50 per cent. There has been exponential growth of motor vehicle use in developing countries such as India and China in recent years, and this technology is likely to play a critical role in reducing GHG emissions levels. Hybrid technology is at the supported technology stage: hybrid cars are commercially available, but still cost significantly more than normal vehicles, so government incentives, such as tax reductions for low-carbon vehicles, will play a crucial role in encouraging the uptake of the technology.

IPR in this sector is strictly controlled. Companies such as GM, Toyota and BAE have strict patents on their hybrid drivetrains – the vital part of this technology. This IPR has allowed Toyota to recoup some of its investment by licensing its drivetrain technology to other companies such as Ford and Nissan. It might also hold back the acquisition of this technology in developing countries. At the moment, two Indian companies, TVS and Ashok Leyland, are working to develop hybrid vehicles.

Toyota has entered a joint venture with a Chinese car manufacturer, Sichuan FAW, and has begun producing the Prius in China. This may allow drivetrain technology to filter into the Chinese economy in the longer term, despite the strict patents on the technology. However, car parts are currently imported from Japan rather than made in China, holding back technology transfer.

Source: Ockwell *et al* 2006

more than 8,500 scientists working in more than 100 countries, drawing together the work of national, international and private sector organisations (Stern 2006b).

Providing adequate finance for new technologies is also crucial. New technologies are often costly and entail higher risks for investors; also, manufacturers are often unable to find economies of scale because, initially, demand is low for new products. While climate change finance facilities such as the Special Climate Change Fund have been mandated to assist the transfer of technology, these funds are inadequate. The Stern Review has suggested that global public energy R&D funding should double to around US$20 billion so that a diverse portfolio of low-carbon technologies can be developed. The review also suggests that, worldwide, financial incentives to encourage the deployment of technology should be increased by a factor of between two and five from current levels of US$33 billion (Stern 2006b).

Further action also needs to be considered on intellectual property rights. During the past few decades intellectual property protection has been extended at unprecedented rates. Changing trade patterns mean that developing countries cannot easily develop their own versions of an imported technology behind strong tariff barriers. Furthermore, the World Trade Organisation Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) has extended minimum standards for IP protection globally. Public policy is supposed to ensure that IP protection brings greater benefits to society (for example, the invention of new technology) than costs (for example, higher consumer prices on vitally-needed technologies). However, the interests of the producer often dominate the evolution of IP policy, leading to developing countries negotiating from a position of weakness, according to the Commission for Intellectual Property Rights (CIPR 2002: 10).

Unfortunately, debates on IPR issues are log-jammed at the UN. The UNFCCC Expert Group on Technology Transfer, the central forum for negotiating these issues, has been unable to reach agreement on a Technology Development and Transfer Board and Multilateral Technology Acquisition Fund that would widen IPR access. The G77/China bloc made a detailed proposal on this issue during the UNFCCC 2006 negotiations; but this was blocked because other parties objected to it (IISD 2006).

India has consistently argued that IPR for low-carbon technology should also be widened (India Government 2005). Policies that could achieve this goal include:

- Developing purchasing commitments as an incentive for the development of new technologies. This would be a binding contract, offered by a government or IFI, used to guarantee a viable market if a new renewable technology was developed.
- Governments voluntarily buying-out private companies' IPR on existing products.
- Compulsory licensing, with government forcing the holder of IPR to grant rights to others (Stern 2006b; India Government 2005).

The IP debate around low-carbon technology is particularly complicated. IPR generally represents a much smaller component of low-carbon technology costs than, say, it does to the costs of HIV/AIDS drugs, due to the size of capital investments and running costs involved. It might be very difficult to successfully choose the most appropriate low-technology IPRs because there are many pathways towards developing a low-carbon economy (Stern 2006b). For instance, should the international community prioritise widening IPR on clean coal technologies or wind turbine technologies? Nevertheless, deep emissions reductions will have to be made in the next few decades using the low-carbon technologies that are currently available. Increasing access to IPR will be a necessary – but not sufficient – part of enabling low-carbon-technology transfer.

The UK played an important role in providing wider access to HIV/AIDS IPRs, and now has an opportunity to adopt a similar leadership role in widening access to low-carbon technologies (CIPR 2002). The Stern Review has already argued that 'the development of new [low carbon] technologies, particularly those with significant public funding, will be conducive to public IPR ownership' (Stern 2006b: 502). The UK is also engaging constructively with developing country concerns and has included the issues of technology transfer and IPR in one strand of the UK-India sustainable development dialogue.

Currently, the debate into IPR is hindered by the lack of an evidential base. More research is necessary to establish exactly how to best promote the transfer of low-carbon technologies (Ockwell *et al* 2006).

Conclusion

India faces profoundly difficult choices when it comes to taking action to reduce greenhouse gas (GHG) emissions. Just as the power stations of the Tennessee Valley Authority and rural electrification corporations were at the heart of the New Deal that transformed the lives of so many Americans, so developing countries demand universal access to electricity and energy to power economic growth. In a world shaped by industrialised countries, India's policymakers argue that it is not developing countries' 'fault' that they, like the developed world, use fossil fuels to meet the vast majority of their energy needs.

In any case, dangerous levels of GHG emissions have been historically caused by developed countries; and developing countries' per capita emissions are low. However, because concentrations of GHG are already so high, action from Kyoto Annex I developed countries will not be enough to avert dangerous climate change: the current emissions growth patterns of the major developing countries will cause disastrous climate change (IISD 2006). And it will be these same countries in the developing world that will be hit hardest by flooding, extreme weather and reduced agricultural yields.

These challenges are particularly acute in India. India may be shining: it has an extremely large, rapidly growing economy. Yet the vast majority of the population literally live in darkness, experiencing very high levels of poverty. Almost half of India's households do not have electricity, and women and girls spend a total of 80 billion hours each year collecting firewood, a fuel that poisons the lungs of 24 million adults (Dubash 2005).

The fundamental goal of climate policy has to be to provide India with clean, cheap energy so that it can meet its social development goals and help avert dangerous climate change. These are issues of social justice and courage is required to discuss the obligations that developed countries owe to their neighbours, as are a new confidence in the power of the state, and a willingness to profoundly reshape markets.

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