INFOCHANGE

agenda

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The big challenge of the new millennium

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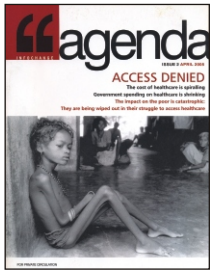

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Energy versus environment: The big challenge of the new millennium

To maintain its rapid economic growth rate, India needs all the energy it can get. But the momentum of economic growth overrides crucial environmental concerns. How can India sustain a high economic growth rate and leapfrog into a sustainable energy regime without irreparably harming the environment?

RAKESH KALSHIAN

MEDHA PATKAR and her fellow Narmada Bachao Andolan (NBA) activists recently went on an indefinite hunger strike in New Delhi to protest raising the height of the Sardar Sarovar dam until all the already displaced families had been properly rehabilitated. Amidst much media hoopla and hectic politicking, the UPA government agreed to review the contentious issue. The review committee did a survey of the ground reality which bore out the NBA's grievances.

But the potato turned out to be too hot for the government to handle and it finally dropped it in the Supreme Court (SC). The SC decided to take the middle ground, issuing an ultimatum to the state governments to complete the rehab work while letting construction of the dam continue. The NBA cried foul but there wasn't much else it could do.

This episode illustrates yet again the inexorable logic of economic growth which often overrides human or environmental "obstacles" that may come in its way. India is well on its way to becoming an economic superpower and, galloping at an annual economic growth rate of 8-10%, it desperately needs all the energy it can harness. Dams, nuclear reactors, thermal power stations, all symbolise this much-needed energy without which the nation's economic horses may slow down.

At this rate, there will of course be environmental casualties. Dams will submerge valuable forests, thermal power stations will lead to acid rain, mining will scar landscapes, industries and transportation will vitiate air and water, and nuclear reactors will pose potential radiation hazards, not to mention climate change, which is arguably the result of carbon emissions produced by burning fossil fuels.

This raises a number of questions: Will India be able to sustain a high economic growth rate without irreparably harming the environment? How long can India depend on oil and gas imports, which account for over 65% of its consumption, especially in the face of rising prices? Should India build more big dams or set up more nuclear power reactors to tide over its energy crisis? Can India continue to rely on its abundant reserves of coal, which currently accounts for over 60% of its electricity production, and still be able to meet its carbon reduction commitments? Shouldn't India invest more in renewable energies like wind and solar while at the same time working towards evolving and creating systems that are less energy-intensive, such as promoting public transport between and within cities? Or evolving a system of incentives and disincentives that persuades people to adopt less consumerist lifestyles so that even as India's economy grows, its energy consumption declines?

Admittedly, energy is a complex subject and there are no easy answers to these questions. A mix of foresight, courage and inventiveness will determine what forms of energy India chooses to power its economic growth with, and whether it could leapfrog into a sustainable energy regime without losing its competitive edge in the world economy. But the way things are moving now, the future doesn't look all that bright and sustainable. A draft report on energy policy authored by Kirit S Parekh, member (energy) of the Planning Commission, paints a rather dismal picture. For instance, in the business-as-usual scenario, India will exhaust its oil reserves in 22 years, its gas reserves in 30 years and its much-vaunted coal reserves in 80 years. More alarming, the coal reserves might disappear in less than 40 years if India continues to grow at 8% a year.

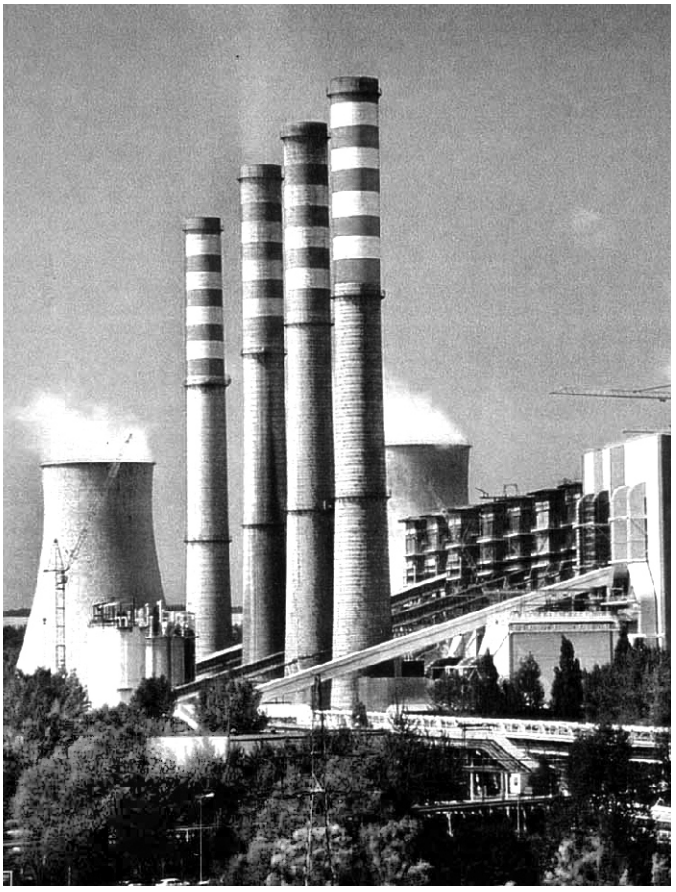
But things might begin to look up if India is able to harness alternative energy sources, such as hydel, biofuels, solar energy, and even nuclear energy. For instance, it estimates that wind energy can generate 10 million tonnes of oil equivalent (mtoe) and energy plantations could contribute 30 to 60 mtoe from about 10 million hectares. This would not only create livelihoods but also provide income in the form of carbon credits that can be sold at 20 euros per tonne of carbon dioxide. Solar energy could contribute a useful 2.4 billion tonnes of oil equivalent for 10 million hectares, says the report.

In the long run, so several gurus of energy have predicted, India may have to move towards greater use of renewable forms of energy, for which it has abundant resources. Globally, the renewable energy industry is no longer in a state of infancy, with global investments in 2004 totalling $ 28 billion as compared to $ 6 billion in 1995. Total installed capacity based on renewable energy was 155,000 MW in 2004, of which wind power itself totalled 48,000 MW. A focused, goal-oriented programme of R&D would bring down costs of renewable energy devices and meet the needs of a diverse range of applications and customers. The Clean Development Mechanism under the Kyoto Protocol was supposed to provide the necessary impetus to popularising renewable technologies in countries like India, but unfortunately, renewable energy CDM projects are conspicuous by their absence.

At any rate, despite contributions from alternative resources, the oil import bill will continue to balloon. Indeed India might be importing as much as 90% of its total oil requirement in the year 2031-32, assuming domestic production will be a paltry 35 million tonnes. Natural gas (including coal-bed methane) imports will be anywhere from 0-66% against a requirement of 77 to 290 million tonnes. The range is pretty wide because it is difficult to say what the fuel matrix will be, with much depending on how alternative fuels are harnessed. In any case, coal will continue to be the main propeller of India's economy, and to meet its spiralling energy needs, coal production will have to increase by four to five times the current level, and rail capacity to move the coal will also have to rise three to four times.

Given such a bleak prognosis of its energy future, India has begun embracing energy resources that were considered unsustainable until recently. Thanks to the threat of climate change and spiralling oil and gas prices, big dams and nuclear power have acquired new currency. The recent Indo-US deal is a harbinger of the changing geopolitics of energy security. Indeed, international financial institutions like the World Bank and Asian Development Bank are no longer averse to funding big dam and nuclear projects. And both hydro and nuclear power might become eligible under the Clean Development Mechanism of the Kyoto Protocol!

But dams and nuclear reactors have long gestation periods and



are fraught with social and political risks. In the short to medium term, India's voracious appetite for energy can only be met by an increasing amount of imported oil and gas. But owing to cold relations with Pakistan and Bangladesh, it can't access gas from Central Asia as the pipeline has to pass through Pakistani territory, while Bangladesh is unwilling to sell its gas or allow a gas pipeline from Myanmar to pass through its territory. Nationalism and oil are proving a volatile mix. Resolving territorial disputes and improving relations with traditional adversaries will become increasingly important for India if it is to meet its energy import needs by peaceful means.

All this implies that India will have to look further afield — to Central Asia, Russia, and even as far as Latin America, for access to gas and oil. The Oil and Natural Gas Commission (ONGC), for example, has invested in offshore gas fields in Vietnam, as well as energy projects in Algeria, Kazakhstan, Indonesia, Venezuela, Libya and Syria, while Indian Oil Corporation is looking to invest in deepwater exploration in Sri Lanka. Reliance Industries, India's largest private sector oil firm, also has stakes in an offshore field in Yemen and a liquefied natural gas project in Iran, and is in talks to acquire energy assets in Nigeria, Chad, Angola, Cameroon, Congo and Gabon in Africa as well as in South America and the Middle East. Indeed the desperation for gas and oil is such that India is even willing to compete for energy resources in some of the most unstable parts of the world such as Sudan and Myanmar. In Sudan, India has invested $ 1.5 billion and it is trying to strike a gas deal with Myanmar's military junta.

So where does the concern for climate change and the environment fit in all this realpolitik over fossil fuels? On the fringes, one would imagine. For instance, the Indo-US nuke deal or the six-nation clean air pact between India, China, South Korea, USA, Australia and Japan makes a mockery of the Kyoto Protocol. India and China have said in so many words that they will not commit themselves to any carbon cuts in the second phase of Kyoto as reducing poverty through economic growth will remain their top priority. The US too backed out of the Kyoto Protocol saying that any carbon reduction commitments would hurt its economy. If the Indo-US deal is anything to go by, the world is more likely to see a shift towards more and more bilateral economic and technological deals to tackle climate change rather than through the dictates of international treaties.

In the ultimate analysis, whether India will eventually be able to shift to a sustainable energy paradigm or not will hinge crucially on how cleverly Indian policymakers can reconcile the material aspirations of a billion-plus people with the laudable goals of equitable access and environmental sustainability. Till then, it's going to be all about survival of the cleverest, about who's going to corner the maximum energy resources at the cheapest rates.

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Hotting up: The science and politics of climate change

The world is hotting up. Climate systems are changing. The 1990s were the hottest decade ever, sea levels rose by 10-20 cm during the 20th century, and atmospheric carbon dioxide levels are 31% higher than in 1750. There's overwhelming scientific evidence to prove that climate change is human-induced and closely connected to energy use and the burning of fossil fuels

ADITI SEN

IT RAINED ALL DAY. It rained like it had never rained before. Trains stopped, cars were submerged, several died, and hundreds and thousands of people waded through the streets of Mumbai. The city that never stands still came to a grinding halt. It almost sounds like a scene from a sci-fi film, but in fact it is scarily real. Mumbai witnessed the heaviest rains ever recorded in India in July 2005. Such catastrophic weather phenomena are often seen as acts of God, and they might well be, but the increasing occurrence of extreme weather conditions in India and around the world points towards a dangerous threat — climate change.

Though floods, drought, storms and other extreme weather conditions have always been a reality, they have been rare occurrences interrupting long periods of calm — sudden outbursts marring nature's largely gentle rhythm. Now, because of human-induced climate change, that gentle rhythm is breaking up. Overwhelming scientific evidence indicates that climate change is real — the world is warming up and climate systems are changing.

The science of climate change

Earlier this year, in February 2006, scientists found that the vast ice sheets over Greenland are melting far faster than previously believed, with twice as much ice going into the sea as was going in five years ago. What happens in the remote Arctic may seem far removed from what happens in the tropics of India, but the implications for climate change could be dramatic. If the Greenland ice sheet melted completely, it would raise global sea levels by about 7 m. The oceans play a pivotal role in the climate system. Changes in ocean circulation or water properties can disrupt this hydrological cycle on a global scale, causing flooding and long-term drought in various regions. The El Niño phenomenon is but a hint of how oceanic changes can dramatically affect where and how much precipitation falls throughout the planet.

Findings from the Intergovernmental Panel on Climate Change (IPCC), which has been established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP), show that the global average surface temperature increased by 0.6°C over the course of the 20th century. Scientists have recorded the 1990s as the hottest decade in the world since the Industrial Revolution began. As a result of global warming, the extent of snow has decreased by about 10% since the 1960s, while mountain glaciers have retreated rapidly. The global average sea level rose by 10 to 20 cm during the 20th century, and the amount of heat stored in the ocean has measurably increased since observations began in the 1950s.

Rainfall patterns have also changed in the northern hemisphere, with generally more rain at high latitudes and near the equator and less in the sub-tropics. Warm El Niño (which causes drought and flooding) episodes have been more frequent, persistent and intense since the mid-1970s than during the previous 100 years.

One of the most important features of the IPCC Third Assessment Report is that it strengthens the conclusion that human activity is driving the observed climate change. The atmospheric concentration of CO_2 is now 31% higher than it was in 1750, the highest it has been for the past 20 million years — and it's accelerating. About three-quarters of the increase is from burning fossil fuels, while the rest is mostly due to deforestation. Atmospheric methane has increased even more dramatically, by 151% since 1750. Nitrous oxide and synthetic greenhouse gases (halocarbons) also continue to rise.

Much of this discussion sounds like technical babble to people. While it may seem like something esoteric that only scientists in white coats need to contend with, its impact on ecosystems, economies and local weather is real. Throughout the 10,000-year history of human civilisation, weather patterns have remained relatively constant, but the frequency of extreme weather events has increased steadily over the 20th century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. These trends confirm the predictions of computer models: as the atmosphere warms, the climate will not only become hotter but much more unstable. Extreme events are likely to increase, and drought and floods will become more common in a number of regions. Many alpine glaciers will disappear, snow cover and the extent of sea ice will continue to wither, and sea levels are projected to rise.

Climate change also raises other important concerns: How will our health be affected by global warming; how will agricultural practices change; how will wildlife cope?

The impact of climate change

Climate change is an issue that threatens the entire globe. However, it disproportionately affects developing countries and

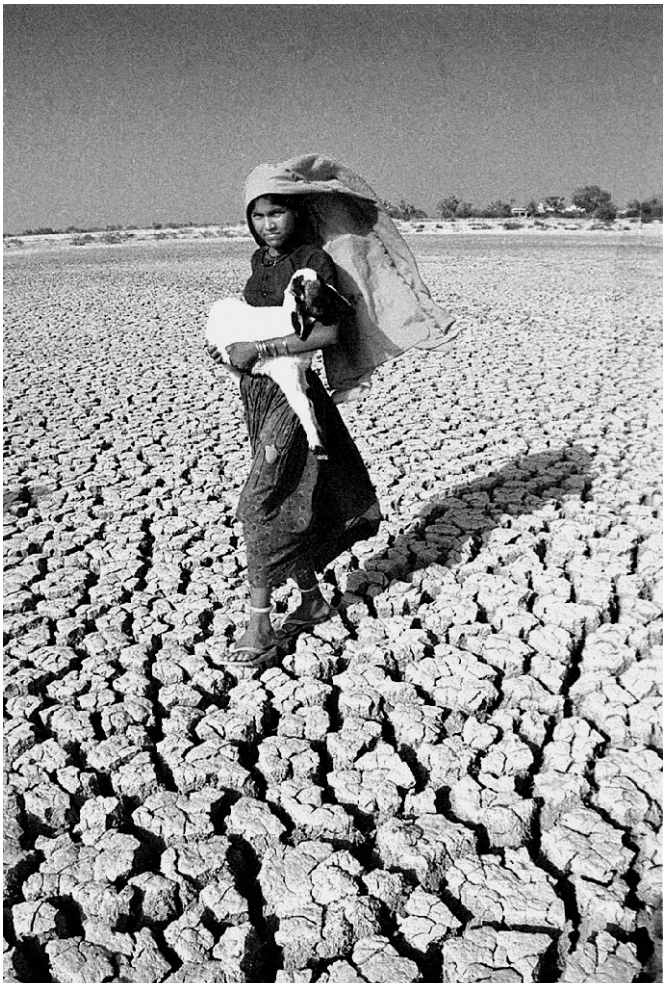
it will be most disruptive to the poorest of the poor — those who have the least resources and the least capacity to cope. Already there are signs that Africa's favourite crop, maize, is struggling to cope with the vagaries of a changing climate. It might even have to be dropped in favour of more traditional crops like sorghum and cassava. So says the first continent-wide study of how crop yields change with major oscillations in global climate such as El Niño and the North Atlantic Oscillation. It concludes that 20 million Africans will go hungry in the years ahead when the climate is not in their favour (proceedings of the National Academy of Sciences, Vol 103, p 3,049).

With its huge and growing population, a long, densely populated and low-lying coastline, and an economy that is closely tied to its natural resource base, climate change could have potentially devastating impacts on India. The average temperature is predicted to rise by 2 to 4°C with a doubling in CO_2 concentrations. With climate change, rainfall patterns are also set to change. Western and central areas could have up to 15 more dry days each year, while, in contrast, the north and northeast are predicted to have five to 10 more days of rain annually. In other words, dry areas will get drier and wet areas wetter. In an almost sadistic twist of events, climate change will make India more susceptible to both drought and flooding. IPCC findings indicate that there will be an increase in the frequency of heavy rainfall events in South and Southeast Asia. Studies have also shown that the impact of snow melting in the high Himalayas will lead to flood disasters in Himalayan catchments.

The most dramatic effects of climate change will manifest in agriculture and forestry. These changes could in turn have profound implications for livelihoods and food security. Agriculture and allied activities continue to be fundamentally dependent on the weather in India. IPCC and other studies suggest that there will be a decrease in yields, though the percentage of decrease varies across different scenarios. Higher temperatures reduce the total duration of a crop cycle by inducing early flowering, and the shorter the crop cycle, the lower the yield per unit area.

Climate change is also likely to have a substantial impact on forestry. Climate is an important determinant of the geographical distribution, composition and productivity of

Raaj Dayal



Ritu Raj Konwar

The number of weather-related disasters such as drought and floods in the 1990s was four times higher than in the 1950s.

forests. Therefore, changes in climate could alter the configuration and productivity of forest ecosystems. In a case study of Kerala (Achanta A and Kanetkar R, 1996), results indicate that under climate change scenarios, soil moisture is likely to decline and in turn reduce teak productivity from 5.40 m^3/ha to 5.07 m^3/ha. The study also shows that the productivity of moist deciduous forests could decline from 1.8 m^3/ha to 1.5 m^3/ha. Changes in forestry could potentially result in the extinction of some species and loss of biodiversity.

The impact on water resources is also expected to be severe. India is considered rich in terms of annual rainfall but these resources are unevenly distributed, causing spatial and temporal shortages across regions. Climate change and variability are likely to worsen the problem of water scarcity that many parts of India face. Under a changed climatic regime, the combined effects of lower rainfall and more evaporation would have dire consequences. Both these would lead to less runoff, substantially changing the availability of freshwater in the watersheds. Also, potential changes in temperature and precipitation might have a dramatic impact on soil moisture and aridity levels of hydrological zones. With changes in flows, annual runoff and groundwater recharge, water available for use will further decrease. Most major river basins across the country are likely to become considerably drier. One assessment (Hadley Centre Model Simulations) indicates that by the year 2050, the average annual runoff in the river Brahmaputra will decline by 14%.

Sea level rise associated with climate change threatens India's low-lying and densely populated coastline that extends about 7,500 km. The UNEP identifies India as among the 27 countries that are most vulnerable to sea level rise. Most of the coastal regions are agriculturally fertile, with paddy fields that are highly vulnerable to inundation and salinisation. Coastal infrastructure, tourist activities, and onshore oil exploration are also at risk. The impact of any increase in the frequency and intensity of extreme events, such as storm surges, could be disproportionately large, not just in heavily developed coastal areas, but also in low-income rural areas. A case study of Orissa and West Bengal (IPCC, 1992) estimates that in the absence of protection, a one-metre rise in sea level would inundate 1,700 km of predominantly prime agricultural land. The economic implications of such a rise could be huge — ranging from Rs 2,287 billion in the case of Mumbai, to Rs 3.6 billion in the case of Balasore (TERI, 1996).

Climate change has other impacts that may seem less obvious at first, but would have very serious socio-economic consequences. For instance, some reports predict that India will be more prone to malaria, as changing weather patterns result in potential breeding grounds for malarial mosquitoes at higher altitudes. Adverse weather patterns will also affect large-scale infrastructure projects that are designed to have a long lifespan. The recently constructed Konkan railway, a major infrastructure project laid through the high rainfall mountain region in mid-western India, is a typical example of a high-value long-life asset exposed to climatic extremes.

The politics of climate change

The science of climate change is not a hundred percent accurate, and different models and simulations suggest different scenarios. But there are certain facts that all scientists are unanimous about — that the earth is getting warmer, that climate systems are changing and that we are already contending with the impacts of climate change. What is also clear is that human activity has been responsible for this. But, despite such unanimous and compelling evidence on global warming the response to this threat has been sluggish and mired in controversy.

Climate change negotiations started more than two decades ago. In 1992, a global Framework Convention on Climate Change was signed under the auspices of the United Nations (UNFCC). The framework recognised that industrialised nations needed to take the first step in reducing emissions because not only were they more responsible for the problem, they also had greater capacity and resources to take corrective action since they had already reached a high level of economic development. The Kyoto Protocol was drawn up in 1997 to implement the UNFCC. According to the Protocol, industrialised nations that sign the treaty are legally bound to reduce worldwide emissions of six greenhouse gases (collectively) by an average of 5.2% below their 1990 levels, by 2008-2012.

However, it took seven years for the Protocol to finally become international law. For it to come fully into force, the pact had to be ratified by countries accounting for at least 55% of 1990 carbon dioxide emissions. With countries like the US and Australia unwilling to come on board, the key to ratification came when Russia, which accounted for 17% of 1990 emissions, signed the agreement on November 5, 2004. But Kyoto still lacks teeth because the United States, which is the world's largest emitter of greenhouse gases, continues to hold out.

So where does that leave us? Emissions in America continue to rise and are now 11% higher than they were in 1990. Most countries that have signed up to Kyoto also admit that meeting their Kyoto targets will be difficult; nations are already falling behind. Spain and Portugal in the EU were 40.5% above 1990 levels in 2002. Canada, one of the first countries to sign up, has increased emissions by 20% since 1990 and has no clear plan to reach its target. Japan is also uncertain about how it will reach its 6% target by 2012.

One of the things that people are excited about as a possible solution and a potential win-win situation for both developed and developing countries is the Clean Development Mechanism. The Kyoto Protocol included provisions for two so-called "flexible mechanisms": Joint Implementation (JI) and the Clean Development Mechanism (CDM). The CDM is supposed to be a market-based way to combat climate change. Through it, developed countries may invest in bankable projects in developing countries by paying the extra cost of upgrading to cleaner technology. In turn, they get credits for the amount of emissions reduced.

The CDM clearly has some immediate and apparent benefits — it brings in cleaner technologies and provides financing to

Carbon rush

In just the last 150 years, human-induced activity has pushed the level of carbon dioxide in the atmosphere from a comfortable 280 ppm to 381 ppm

99% of the earth's atmosphere consists of nitrogen (78%) and oxygen (21%). Both these are responsible for complex biogeochemical cycles that support life on the planet. But they play little direct role in regulating climate. The remaining 1% is made up of small amounts of 'trace' gases like argon, water vapour, carbon dioxide, nitrous oxide, methane, chlorofluorocarbons (CFCs) and ozone — all of which are important in the regulation of climate. These trace gases are known as greenhouse or radiatively active gases (those that absorb or reflect infrared radiation).

Carbon dioxide represents just a few hundred parts per million (ppm) of the overall atmosphere, but this tiny component (0.037% of the atmosphere) helps warm the earth to a comfortable level. Too much of this gas in the atmosphere can do a lot of damage, however, because it is CO_2 that allows sunlight to stream in but prevents much of the heat from radiating back out. During the last Ice Age, the atmospheric concentration of CO_2 was just 180 ppm, freezing the earth. After the glaciers retreated, the total had risen to a comfortable 280 ppm. In just the last 150 years, we have pushed that level to 381 ppm. As a result, the earth is heating up. Of the 20 hottest years on record, 19 occurred in or after the 1980s.

Are increases in trace gases, particularly CO_2, the result of people's activities? The vast majority of scientists believe so. First, the increase is much larger than the natural variability of CO_2 concentrations over thousands of years. Second, they know how much coal and oil Industrial-Age societies have burned and how much forests they have cut down, and these factors are enough to account for the increase. The combustion of fossil fuels like coal, oil and gas, takes carbon that has been locked beneath the earth's surface for millions of years and releases it into the atmosphere. Third, isotope analysis of the carbon in atmospheric CO_2 suggests that much of the increase did come from the burning of fossil fuels. Fourth, complex models of the carbon cycle that represents important processes and feedback between the atmosphere, biosphere and oceans cannot explain the observed changes in CO_2 without the human component.

Anthropogenic emissions of carbon dioxide from fossil fuel combustion and cement production reached a peak of about 6.6 GtC/year in 1997 (0.2 GtC/year of that was from cement production) and continues an upward trend, averaging around 6.3 GtC/year over the 1990s, an increase from an average of 5.4 GtC/year during the 1980s.

projects in developing countries. But on closer inspection, the deal is not as attractive as it seems. The system, as currently proposed, risks being no more than a way for wealthy countries to buy their way out of their obligations, without significantly reducing domestic emissions. These markets do not create the right conditions for the structural change needed to tackle global warming. On the contrary, they shore up the fossil fuel status quo while blocking constructive alternatives. Some developing nations, most notably India, have argued moreover that North-South trading mechanisms are inherently unfair. The way it is currently designed, the emissions-trading regime is based on an inequitable distribution of atmospheric property rights — in other words, the right to emit carbon dioxide is not the same for all individuals on this planet. The industrial nations, for instance, decided on 1990 emissions as a baseline for allocating emissions rights to ensure continuity of their economies.

Despite the criticisms against the CDM in terms of its operational inefficiencies and the ideological battle surrounding it, the 2006 Montreal Climate Conference which was touted as the "son of Kyoto" enshrines market mechanisms and emissions trading as the key policy response to climate change.

While neither the Montreal conference of 2006 nor the G8 summit of 2005 provided any breakthroughs, they represent a small step forward in building a consensus around the issue. It sets the stage for a dialogue on long-term climate change management beyond 2012, which is the last year of the Kyoto Protocol. On the last day of the Montreal conference, Kyoto Protocol signatories agreed to extend the treaty on emissions reductions beyond its 2012 deadline. Formal talks can now begin over the precise targets that will be set when the first phase of the Kyoto agreement expires in 2012. Montreal also sets the scene for discussing how large developing countries like India and China can be brought into the system of limiting greenhouse gas emissions.

Moving beyond deal-making and bargaining, some pressing questions have been left unanswered by Montreal, Kyoto and the other multilateral negotiations. The move from fossil fuels to renewable energy alternatives has not been fully considered. At home, India's growing economy means an insatiable appetite for energy, but it needs to look at its energy policy more carefully. Given the subcontinent's extreme vulnerability to climate change, this is a battle that will ultimately be fought in our own backyards. So we had better gear up for it.

This article is primarily based on findings from the IPCC and UNFCC. Other specific studies have been cited when used. Aditi Sen works in the Environment and Socially Sustainable Development (ESSD) Network of the World Bank in Washington DC. The author has written this article in a personal capacity. The views represented here are the author's alone

Confused about climate

Journalists reporting on the arcane science of climate and the environment have to grapple with new and often conflicting theories and findings from scientists and sceptical environmentalists virtually every month. What does the bewildered journalist do in the circumstances?

DARRYL D'MONTE

IN JANUARY THIS YEAR, the authoritative journal *Nature* published an article that put the cat among the pigeons by asserting that plants produce up to a third of the second biggest greenhouse gas, methane. Until then, it had been assumed that this damaging gas is only produced by paddy fields, rotting vegetation and the digestive tracts of ruminants. This had been the conventional wisdom, and growing trees was seen as one of the most important ways of trapping or 'sequestering' carbon from the atmosphere.

This development illustrates graphically the difficulties that those who report this arcane science have to confront virtually every other month. If even the world-renowned UN Intergovernmental Panel on Climate Change (IPCC), headed by Dr R K Pachauri from The Energy and Resources Institute (TERI) in Delhi, has missed such a connection, the fate of the journalist who has to tackle this complex issue can well be imagined.

It gets curiouser. With climate change, particularly with huge emissions of carbon dioxide, plants will grow more vigorously — thereby only adding to the load of methane, which is released in smaller quantities than carbon dioxide, but stays in the atmosphere for much longer. Indeed, the reason that methane levels have not been growing globally, the researchers say, may well be due to heavy deforestation.

What does the bewildered journalist do in these circumstances? He can, as many reporters do, simply report the 'facts'. But since there are contradictory facts by the month on global warming, how is s/he to choose between fact and fiction?

One of the solutions is to judge the source of the story. In this case, it was reported in *Nature*, a prestigious peer-reviewed journal (not that they are necessarily infallible). And, what is more, the research team was from the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, which is internationally reputed too.

This February, I asked Professor F Sherwood Rowland, a Nobel laureate from the University of California who is one of the world's foremost authorities on climate change, about this change of mind. Admittedly, I caught him unawares as we were leaving a session at the Delhi Summit on Sustainable Development. He replied that it was a question of exactly how much methane as a proportion of the total was emitted by greenery. His team has for nearly 30 years been taking air samples from across the globe to measure changes in the atmosphere. His answer may not have satisfied the uninformed scribe, but the very fact that he did not dismiss the Max Planck findings out of hand speaks for itself.

If such scientific hair-splitting is confusing, spare a thought for the reporter who is confronted by the climate sceptics. For years, there has been a cleverly orchestrated campaign by the oil lobby and multinational companies, with front organisations like the Global Climate Coalition, which have tried to discredit the very fact of global warming, rather like the tobacco and asbestos industries did with health scares relating to their products. Newspaper proprietors like Rupert Murdoch seem to take great delight in knocking global warming whenever they can: *The Sunday Times* in London, once an exemplar of investigative journalism, has carried several stories which record the contrary point of view.

This refutation achieved its apotheosis prior to the World Summit on Sustainable Development in Johannesburg in 2002 with the publication of Danish scientist Bjorn Lomborg's aptly titled *The Skeptical Environmentalist*. That he was a scientist and an environmentalist lent credence to his allegations of scare-mongering on the part of the scientific community. But this is where the media can exhibit some common sense. The IPCC consists of some 1,500 climate scientists around the world: to believe that they have a vested interest in scaring the world about the changing climate in order to raise more funds for their research is to fall prey to conspiracy theories of the worst kind. Lomborg's 'facts' have since been shown to be scientifically incorrect.

The situation in this country is doubly or trebly complicated by the fact not only that there are few journalists who are well-informed about this issue, but that sources of information on India's situation are few and far between. Admittedly, it is important for journalists here to concentrate more on adaptation to climate change rather than mitigation, which is rightly the concern of industrial countries in this phase of the Kyoto Protocol. There is precious little research being done on this all-important phenomenon, although the signs are visible for anyone who cares to look.

The ministry of environment, the Indian meteorological department and other official agencies down the line ought to be aware that perennial drought and floods are signs of climate change. There is a secular rise in temperatures within the country, the monsoon is becoming increasingly erratic (even if total precipitation remains roughly the same), and there are

disturbing warnings that the glaciers are melting in the Himalayas. Since India has an 8,000-km-long coastline, and one of the predictions is that ocean levels will rise during this century, all coastal populations are at risk.

There was a premonition of such potential catastrophe when Mumbai received 944 mm of rain on July 26 last year, about half of it in just four hours. Although no one can confidently assert that the deluge was due to global warming, Pune meteorologists believe that it was a localised 'supercell', where a cloudburst occurred over north Mumbai. What we do know is that the monsoon is a global phenomenon, intimately connected to ocean temperatures: thus Hurricane Katrina intensified due to the fact that temperatures in the Gulf of Mexico were unusually high. Disturbances like El Niño and El Niña all contribute to the instability of the monsoon.

Without much scientific hair-splitting, any journalist ought to assess that this country is paying a higher price each year due to such variations in climate. He should therefore pay much more attention to the causes (locally) and consequences of such developments. In Mumbai, for example, only after 26/7 has the media 'discovered' the Mithi river and the role it plays in draining one of the world's most populous cities when there is excessive rain. 'Adaptation' to such changes would also include identifying which communities are at risk — typically, the hutment-dwellers in low-lying areas.

Around 80 million people in India migrate internally every year due to drought, floods or other 'natural' causes, which should convince anyone that we are already facing the consequences of climate unpredictability. But the long-term causes of such occurrences are never examined.

Some time after 2012, depending on how negotiations go, India, China and other developing countries will also have to curb their emissions of greenhouse gases. That will really place a question mark on the extremely inefficient use of energy in every sector — the proportion of energy to unit of GDP is inordinately high. The media thus has an obvious agenda on climate change: we have to report wasteful and polluting practices in every sphere sooner rather than later.

As was evident at the Delhi summit, companies are gung-ho about taking advantage of the Clean Development Mechanism by which industrial countries can buy carbon credits for countries that are not yet subject to the Kyoto Protocol. But the problem will arise when developing countries themselves have to buy such certificates in future, when they will be traded at a much higher price. The business media, which is flourishing, could surely track what India stands to gain or lose on trading in such deals on the climate.

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Sudharak Olwe

Low on fuel: Crisis ahead

With costs of oil and coal rising, and crude imports growing, India is facing a huge energy crisis. If we are to reduce demand, boost efficiency and design small-scale, decentralised energy options, we must incorporate the consumer in decision-making

D NARASIMHA RAO

INDIA'S ECONOMIC ENGINE is burning hot; its GDP growth has been bullish, the stock market crossed 10,000 for the first time, services and exports are growing. After emphasising de-control in the 1990s, the government has floored the gas pedal of government-facilitated development schemes such as the Golden Quadrilateral and the recent National Urban Renewal Mission. Unfortunately, we are running low on fuel — literally.

The Planning Commission's recent Integrated Energy Policy (IEP) (see box) provides a good overview of our energy concerns, but does not portend the looming crisis. We are already seeing signs of the crisis — sustained energy price increases in oil/gas and coal, runaway growth in crude imports, irreversible environmental damage. The government appears to bank its hopes in the short-term on offshore fuel supplies — nuclear fuel from the USA and Russia, imported natural gas (LNG) from the Middle East, and, to a lesser extent, imported coal from Indonesia and Australia. But these options pose grave security concerns, may materialise later rather than sooner, and carry a high and volatile price tag. Some lone voices of sustainable development have been shouting themselves hoarse: reduce inefficient consumption, encourage replenishable sources of energy, integrate environmental protection into energy planning, and decentralise decision-making.

The IEP acknowledges only the first two, but too far down the list from coal and gas, which will dominate the fuel mix under any circumstances. Unfortunately, it also suffers from 'targetitis' — the Commission adopts a fire-all-cylinders policy approach, setting targets and broad policy outlines for a smorgasbord of supply-side and demand-side options, without revealing the cavernous gap between targets and the status quo.

The grim reality is that institutional reform — the single largest impediment to correcting price distortions and releasing supply constraints — has not been sufficiently addressed (see box). The IEP emphasises markets, market pricing and strong regulatory frameworks for monopoly sectors. These are easier said than done (particularly with coal and railways). The continuing governance failures of our service delivery agencies (electricity and water utilities, municipalities) thwart any realistic effort to incorporate the customer into solution-building. Without this, we will not achieve the set targets for energy efficiency and demand reduction, nor will we generate incentives to design small-scale energy supply options. Ultimately, this could be the difference between an imminent and a potential energy crisis.

Taking stock of energy consumption: The demand side

India's commercial and total primary per capita energy consumption was 350 kgoe (kilograms of oil equivalent) (TERI 2004) and 479 kgoe (IEA 2004) in 2003-04, both of which are about a fifth of the world average, and less than half of China's. The rate of growth of energy consumption has been 2.5% from 1993-2003 (EIA 2003), as compared to an average GDP growth of 6.8% since 1994. India's per capita installed electric capacity in 2001 reached barely 0.1 kW, compared to 0.25 kW in China, and 3 kW in the US. Most states provide intermittent power for eight hours or less a day to rural areas. Clearly, energy consumption needs to grow at a higher rate than at present.

What has been the composition of consumption and growth? Non-commercial energy, which constitutes primarily biomass and waste products, constitutes less than 30% of total energy consumed, while it used to be close to 70% 50 years ago. This has led to an increased reliance on emission-intensive fossil fuels, such as coal and oil. Industry and transportation dominate commercial energy consumption, comprising over 70% of the total. Energy consumption by industry is mainly in the form of electricity, which has grown at 5% from 1993-94 to 2001-02 (TERI 2004).

Draft Integrated Energy Policy: Failure to integrate energy and environment

The Integrated Energy Policy presented in December 2005 by an expert committee at the Planning Commission provides a comprehensive assessment of India's future energy needs, constraints, and supply options. On the positive side, the document acknowledges the diversity of concerns we face, including fuel shortages, environmental impact and institutional and supply constraints.

Substantively, it projects fuel mixes for different growth and policy scenarios. No matter how aggressively we develop non-conventional sources of energy, or hydro and nuclear energy, coal and natural gas will under all circumstances carry the burden of 50-70% of our energy needs. The report thus develops preliminary policies for the coal and oil/gas sectors. These focus on creating strong regulatory frameworks to foster private investment, technology development (such as coal-bed methane, coal gasification), market-based pricing, and competition. In addition, the report contains elements of policies for power sector reforms, energy efficiency, and renewables.

The expert committee leaves no stone unturned in addressing our energy shortages, as it recommends a smorgasbord of supply-side and demand-side options that would please everyone from George Bush to environmentalists: augment all possible energy sources — domestic and imported; unleash market forces to correct price distortions and discipline state-owned institutions; pursue energy efficiency initiatives, demand-side management, targeted subsidies to the poor, subsidies for renewables. Towards environmental protection, the expert committee makes a glib recommendation to internalise externalities into markets through taxes or other mechanisms. Climate change gets referenced for completion, wherein they document India's participation in the Kyoto Protocol. Unsurprisingly, the committee does not recommend any specific policy measures on climate change, since that would contradict India's stance.

Despite the urge to question the policy's practicality, one cannot expect a roadmap for implementation from a high-level policy document. However, one can expect the committee to recognise today's ground realities, and assign priority to those recommendations that need greater government attention and support. Here, the policy document falls short. While the emphasis on coal and gas policy is understandable, the neglect of other equally important options is not. Specifically, the linkage between energy and the environment, and the failures of the current regulatory framework to mitigate environmental damage, have not been sufficiently dealt with. The committee ought to have recognised the need for an integrated energy and environment policy in this effort.

Second, the policy relies on market forces to address institutional failures. However, markets cannot fix institutional failures in monopoly industries such as state-owned utilities, and governance failures within government. These failures will directly influence the achievement of the committee's policies and performance targets.

The transportation sector has grown rapidly, particularly passenger vehicles. Through the 1990s, passenger cars grew at an average rate of 11.4% per year (INSIGHT 2001). Two-wheelers grew at a staggering 13.6% from 1999-2000 to 2004-05 (CRIS-INFAC 2005), and over 11% from 1992-2000 (India Infoline). From an energy perspective, two-wheelers, which account for over 70% of vehicles on the road, have much more efficient fuel consumption than cars. On the downside, their emissions are poorer, particularly of carcinogenic pollutants such as lead and carbon monoxide.

A third of the vehicles registered in India ply in 23 million-plus cities, where congestion and pollution have increased, and autorickshaws are the predominant mode of public transport. Road transport has gradually replaced railways as the preferred choice for freight and passenger traffic (the share of the railways has dropped by half since 1989, to 30% and 15% in 2003-04 for freight and passenger traffic respectively). This does not bode well for quality of life. Given that the transportation sector accounts for more than half of India's petroleum consumption, the burden of increasing oil imports on energy security, and rising fuel costs, is largely on account of the transportation sector.

The IEP cites mass transportation systems as the sole policy remedy for city transportation. But the role of municipal governance is underestimated. Municipal service providers control land development, city planning, enforcement of emission limits, and traffic management, all of which influence the growth and environmental impact of passenger vehicles. These are equally important.

Energy intensity

How efficiently do we consume energy? The energy intensity (energy use per unit of GDP) of India's industrial output (25,460 Btu/$) is more than three times that of the US (9,521 Btu/$), and four times that of the UK (6,247 Btu/$), but appreciably less than that of China (33,175 Btu/$) (Source: EIA 2003).

Commercial energy intensity has marginally decreased through the 1990s (TERI 2004), and in some key energy-intensive industries such as cement and steel. However, these are still well above international standards (Sathaye *et al* 2005), as is that of India's paper and pulp industries. Unfortunately for Indo-China 'comparophiles', energy intensity in China has been reducing at the rate of 5% per year from 1993-2003, compared to 1.8% in India (EIA 2003). This means that China's energy efficiency of production will soon surpass that of India.

The efficiency of electricity consumption and production is dismal. On the consumption side, low per capita electricity

consumption belies inefficiencies in consumption since it averages the consumption of those who receive virtually no power with high-intensity users. Prime movers (motors) and lights constitute the bulk of consumption. Virtually all lights, barring those in new commercial buildings and government offices, are incandescent, which have one-fourth the efficiency and life of fluorescent lights. A compact fluorescent light (CFL) programme for residential users can reduce system demand by 5% (author's estimate, based on realistic demand composition: 25% residential demand, 40% of which is lighting, of which half adopt CFLs). Old and constantly refurbished motors (pumpsets) in the agricultural sector consume up to double the energy they ought to. Further, agricultural consumers pay flat rates and pump water wastefully. Numerous studies have shown that consumption may actually reduce if farmers are provided metered, reliable power. Similarly, municipal water utilities contribute to the bulk of energy wastage in cities, from excessive pumping. Addressing these demand-side concerns also requires facing governance (accountability) failures at the municipal and state level, where market forces may never reach.

The energy impact of inefficient production includes fuel consumption and the indirect energy consumption needed to build power plants and delivery systems. The most obvious energy burden is that of high technical distribution losses, particularly in rural areas. Furthermore, poorly-maintained capacity and imprudent capacity-planning lead to under-utilisation of existing and future capacity. The plant load factor of India's stock of power plants has steadily increased to just over 70%. This is mostly due to fuel shortages, but also low availability from degradation, and disrepair. Dozens of coal power plants in Orissa, Bihar and other eastern and northern states have not reached even 60-70% of their rated capacity for years (interviews with various power sector personnel, regional system operators, regulators). If management of these plants were improved, and greater accountability forced on power planning, our capacity needs, and therefore energy intensity, would decrease.

Market forces may not, and in some cases will not, reach electric utilities, because they will always be monopolies. We need to reform and improve the regulatory agencies that discipline these utilities as well. They need to treat efficiency improvements on a par with supply additions, because these are equivalent from a supply adequacy perspective.

Further, improving energy intensity frees up resources. But freed up resources need to be channelled appropriately to where they are needed most. This means, among other things, focusing on rural energy needs, a policy for which is still pending under the Electricity Act 2003. This will require a paradigm shift in planning and policy, away from centralised planning and provision, through the strengthening of local institutions.

The supply side: Where do we stand?

India's fuel mix has stayed reasonably fixed for the last few decades, with one noticeable change: increased use of natural gas. Coal supplies 55-57% of our commercial energy needs, oil about 30%, gas 8%, hydro 5% and nuclear 1%. The main shift has been in the growth of natural gas, which now contributes over 10% of electricity production from almost nothing in the 1980s. Towards electricity production, coal contributes about 58% (but over 80% in energy terms), hydro 26-27%, nuclear 2.5%, diesel 1%, and wind 1.6% (TERI 2004, IEP 2005).

Where are the supply constraints?

Coal has the highest and most dependable reserves, but reliable supply is stymied by institutional failures in the state-owned coal and railway industries. The supply constraints manifest, in part, in price trends. Coal pithead prices have increased steadily at 9% from 1990 to 2000, while inflation was 8% on average in this period. These prices do not account for the supply shortages that have been causing persistent reductions in power plant output.

Hydro supplies 27% of electricity needs today. This share will only decrease with time. Hydropower is monsoon-dependent and thus reliably unreliable; the northeastern states contain abundant untapped resources, but may entail high — possibly prohibitive — social and economic costs (of transport to load centres). Until and unless power planning and governance becomes more democratic and equitable, and projects get smaller in scale, hydropower potential will remain just that — potential.

The future of the nuclear industry depends on international fuel supplies. Apart from the obvious security risk this raises, scaling up commercial nuclear power raises many other concerns. Nuclear power has hidden costs, both economic (overruns) and environmental (waste disposal), and would make hardly a dent in energy needs at our rate of project development (over 15 years for Kaiga I and II).

Natural gas appears to have the greatest potential to become a stable supply source, if the domestic gas discoveries in the Krishna-Godavari basin are an indication. However, when and at what cost these will reach the burner tip is unknown. Natural gas reserves indicate nothing of the commercial viability of supply, while imported gas may be expensive (the global LNG transport market is highly constrained).

Oil, like nuclear energy, depends entirely on crude imports for future growth. Crude production has stagnated, while imports have grown to 75% of crude consumption (Indian Oil 2004). Wind has limited, but as yet untapped, resource potential, but first needs to surmount the chicken and egg hurdle with respect to scale and affordability.

Thus, each domestic fuel source is saddled with its own share of daunting supply constraints — be they institutional, economic, environmental or technical. The IEP is not wrong in recommending a multi-pronged effort to improve energy supply and consumption efficiency. However, our ability to achieve these outcomes hinges critically on institutional and governance improvements, both in regulatory agencies and service delivery agencies, which manage consumption and plan future resource requirements.

Energy and climate change

India is one of the largest emitters of carbon dioxide (CO_2) behind the US, China and Japan, and contributes about 4% of

world CO_2 emissions (EIA 2003). It also has the highest CO_2 emissions growth rate (4.2%, 1993-2003) among the top seven emitters, including China (3.2%). India has not committed to a reduction in greenhouse gas (GHG) emissions, though it is a signatory to the Kyoto Protocol.

Coal and oil emit two to three times the CO_2 compared to natural gas, depending on the type of combustion. Given electricity's dependence on coal, and relentless passenger vehicle growth, the emissions trajectory seems unchangeable. Just to stem growth, let alone reduce it, would require a drastic shift away from coal and oil.

But we need to shift away from coal and oil anyway. Even the IEP, which does not embrace climate change as a policy imperative, acknowledges that energy security concerns, local environmental pollution, and supply risks necessitate reliance on a diverse fuel mix and reduction in oil imports — both of which imply a reduction in coal and oil. But what will we realistically adopt instead?

Clean coal and coal gasification would have the highest absolute impact on emissions from any single technology. Significant R&D efforts need to be put into this. Fortunately, this can be done within the current institutional structure.

In our centralised planning environment, large-scale nuclear and hydro also become natural 'carbon-free' solutions. However, would emissions reduction justify the waste disposal risks and costs from scaling up nuclear capacity? Large-scale hydro is also carbon-free, but has an appalling track record of ecological and social damage. Our environmental regulatory framework has been largely dysfunctional. If we embrace climate change policy, we need to simultaneously address this or risk unpalatable environmental trade-offs.

As the IEP shows, the fuel mix has limited sensitivity to non-fossil supply alternatives within a centralised planning paradigm. As discussed earlier, the technical potential for grid-connected wind and biomass deployment is limited to less than 5% of the fuel mix. But with decentralised, stand-alone systems for rural energy, individual loads would require lower energy output and hence lower resource requirements, thereby increasing potential sites for widespread biomass/wind deployment. Beyond these, solar is the ultimate 'backstop' technology. The future of solar's commercial viability depends on the global market, but indigenous R&D should be encouraged to improve resource assessment and exploit domestic cost advantages.

Our energy security, supply inadequacy and environmental concerns — including climate change — dovetail into the need for decentralised, consumer-influenced decision-making. The efficacy of regulatory frameworks to induce cost-effective clean coal and gas supply also depends on transparency and consumer participation. Neglect of the consumer is perhaps the greatest oversight of our policymakers.

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Impact of market reforms on energy consumption

Conventional wisdom suggests that market liberalisation has led to indiscriminate consumption and increased reliance on fossil fuels. However, this is not the case. The main casualty of reforms, from an energy consumption perspective, has been transportation. Liberalisation of the automobile industry, aggressive urbanisation and support of road infrastructure have contributed to the increase in passenger vehicles, and therefore reliance on oil imports. Other than this, some sectors such as cement and steel have reduced energy intensity due to the forces of competition. Overall, the commercial energy intensity of the economy has marginally declined through the 1990s. The fuel mix of commercial energy use has remained fairly constant through the 1990s, but for an increase in the use of natural gas, which is environmentally benign relative to coal and oil.

Rather than worsen fossil fuel reliance, market and private sector-oriented structural reforms have had an indirect, and perhaps deeper, impact on energy consumption. The single-minded focus of structural reforms on private sector participation has been at the expense of governance and institutional reforms, particularly of state-owned utilities, regulatory agencies and municipal service providers. These have perpetuated inefficient management practices, and consequently inefficient energy consumption, production and delivery. For example, electricity sector inefficiencies depend more on regulatory efficacy than on open access markets; expensive captive power units proliferate in industry because of utilities' governance failures; gross wastage in potable water supply and agricultural pumpsets arise from institutional failures in water and electricity boards; indiscriminate land development and absence of mass transportation systems contribute to the proliferation of vehicles.

The future planning of electricity supply, the development of mass transit and planned cities, as well as development of rural energy options, all depend on the efficacy of government institutions. The introduction and functioning of markets themselves require effective governance.

Mobility: At what cost?

Transport contributes nearly one-fourth of the world's greenhouse gas emissions. In India, there has been a 200-fold increase in vehicle population between 1951 and 2002, placing a heavy demand on petroleum. Emissions from passenger cars are expected to grow at 5% per annum, and from aviation at 4% per year. Are there solutions?

CHELLA RAJAN

IMPROVING ACCESS TO THE GOODS AND ACTIVITIES that enhance human welfare — jobs, businesses, schools, shops, leisure and so on — is one of the principal tasks of development. Urban areas, which by definition are spatially concentrated areas of economic activity, see the greatest demands on access. As cities grow in size and function, a complex spatial economy begins to develop around land availability, and access becomes increasingly expensive. Quite often, the most valuable urban land is located closest to desirable centres of activity and those who cannot afford to live in these parts need motorised modes of transport to improve access. And where there is a limited supply of public forms of such transport (for example, buses, metros, light rail), people are forced to rely on private (two-wheelers, cars) and quasi-private modes (autorickshaws, taxis), which are generally more expensive. For those who cannot afford the latter, the situation becomes especially dire, as they spend much valuable time on bicycle or on foot, trying to reach their destinations.

Instead of characterising the problem of transport as one involving the equitable provision of access, many governments tend to assume that the fundamental need is for mobility and hence spend most of their efforts on building roads and other types of infrastructure to facilitate the movement of traffic. But wherever this policy has been adopted, access has worsened rather than improved, especially for those who are least able to afford private vehicles. In fact, even for car and two-wheeler users, having more roads simply means that the urban boundaries have grown and the distances they need to travel to get to their destinations have increased.

From an environmental standpoint, this strategy is disastrous. Transport contributes nearly one-fourth of the world's greenhouse gas emissions; it causes serious problems of urban air pollution and is thus a major hazard to public health. The entire infrastructure to support transport systems is tied to numerous other local and regional environmental problems, including sprawl, oil spills, depletion of freshwater resources and groundwater pollution. And transport is one of the leading causes of death and injury in many countries, due to traffic accidents.

India's transport policy over the past half-century is illustrative of this bias towards expanding infrastructure at the cost of equality of access. Between 1951 and 2002, there was a nearly nine-fold increase in road length and a nearly 200-fold increase in vehicle population. To be sure, much of this infrastructure was vital to connect cities and towns around the country. But a considerable degree of road expansion took place within urban areas, which is reflected in the explosive growth of two-wheelers, now comprising 70% of all vehicles.

Two-wheelers are the most affordable means of motorised private transport, but their proliferation simply means that alternative means of access such as public transport and planning to integrate jobs and housing are simply not working. In addition, the transport of goods by road is now increasingly (growing at about 12% per year) replacing the much cleaner option of rail, to the detriment of the environment.

The rising demand for access within cities has been met through ad hoc approaches that include excessive emphasis on increasing private access to mobility at the cost of mass transport. Thus, public transport in virtually every Indian city is overcrowded, poorly maintained, unsafe, and slow. Many state and municipal governments have instead promoted motorisation, often through hidden subsidies on roads, vehicles, and parking, even though this has led to congestion, urban sprawl and numerous environmental problems and has further limited mobility for the poor. The most environmentally friendly modes, namely pedestrians and bicycles, are given the least space and are subject to hazards from faster and heavier vehicles. Nearly 90,000 persons are killed and about 500,000 injured each year in road accidents, the overwhelming majority of whom are pedestrians and bicyclists.

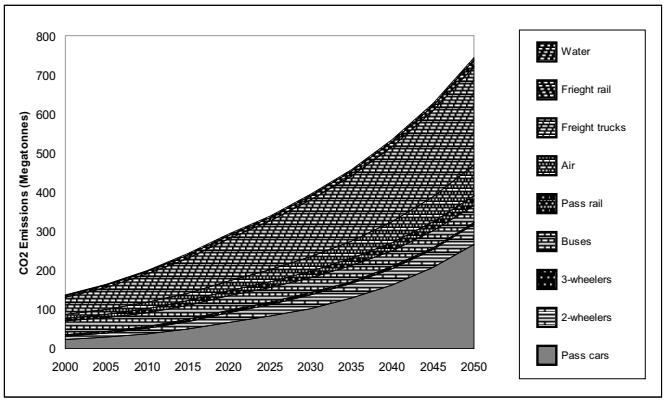
India's greenhouse gas emissions from the transport sector are relatively modest at present in comparison with China, Europe and the USA. The statistics are somewhat misleading, however, because they hide the fact that people's needs for access are not only poorly served but that poverty keeps a lid on the purchase of motorised vehicles. Even so, less than a third of India's petroleum demand is met by domestic production; the rest is imported, causing severe downward pressure on its current account. Currently, the biggest demand segment is freight, unlike developed countries where emissions from private passenger transport are more significant than emissions from freight. This is expected to reverse in the next half-century or so, though both modes will be competing for the dominant share of greenhouse gas emissions from the transport sector (34% and 36% of transport emissions for freight and passenger cars, respectively; see graph).

Emissions from passenger cars are expected to show the

greatest growth in the coming decades (roughly 5% per year) and will dwarf emissions from two-wheelers, even though the latter will continue to capture the dominant market share of passenger vehicles. This is, of course, because two-wheelers are significantly more energy efficient than cars, but not necessarily more sustainable, given their poor safety record.

The rise in aviation-related emissions will be almost as impressive (at just over 4% per year). But while aviation's overall share will be relatively low (about 10% of CO_2 emissions from transport by 2050), it is of particular concern for at least three reasons. First, it is highly energy-intensive, using more energy per person kilometre than a single-occupancy car. Second, its contribution to global warming is around three times greater than is indicated by carbon dioxide emissions alone. This is due to a number of factors including the warming effects of other greenhouse gases that aircraft release in the upper atmosphere. Third, its speed enables and encourages people to travel long distances and its use is increasing rapidly. These factors combined have led aviation to now represent by far the fastest growing source of greenhouse gas emissions. The associated problems have been combined with the fact that aviation has a privileged position in the economy and that, as with car travel, any year in which higher levels of traffic are recorded is interpreted as 'a good year' and encouragement drawn from any evidence indicating the prospect of more growth. Furthermore, aviation statistics are seldom treated with any seriousness in climate policy; indeed, there is no mention of aviation in the national communications of the government to the United Nations Framework Convention on Climate Change.

Expected growth in CO_2 emissions in India from different transport modes



Source: IEA/SMP transportation model

Change in the transport sector is complicated by the fact that it is a dynamic system having intricate links with land use, emissions and the economy. Transport systems require long lead times to change, often entail expensive investments in infrastructure and, even more importantly, significant changes in institutions and political culture. But, given these stipulations, approaches to reconcile the needs of transport services and those of sustainability are well known and involve two complementary routes. The first would be to make use of appropriate policies and modern technologies to encourage the flexible use of vehicle modes and technologies and thereby minimise the adverse impacts of transport. The second would be to apply planning strategies and induce lifestyle changes to

improve access and reduce the need for motorised transport.

The first approach would be to apply policies and make investments to encourage modal shifts and adopt cleaner and more efficient vehicles and technologies. Priority would be given to systems of mass transport over individual car use, for example through the use of economic tools like fuel and vehicle tax regimes. Where car use is likely to persist, such tools could be used to encourage less polluting vehicles, including hybrid vehicles and zero-emission vehicles, including non-motorised modes. Convenient and well-designed systems of high-speed rail could be introduced along busy regional corridors to reduce air travel, inter-city road travel and freight. Technological developments like intelligent transport systems could be used to introduce and guide road pricing; the development of national transport information systems for the various modes can help improve the planning of inter-modal transport.

Successful examples of public transport systems — such as those in Hong Kong (China), Curitiba (Brazil), and Bogota (Colombia) (see box) — may offer lessons for Indian cities. Where feasible, rail freight would be encouraged over road and air freight, and transport through sub-surface pipelines would replace vehicle transport.

Several technologies and strategies are available for reducing pollutant and greenhouse gas emissions from vehicles. The major approaches are alternative-fuelled vehicles, vehicle efficiency improvements, fuel quality and pollutant emissions improvement, transport demand reduction, and mode shift. Among the categories of policy that could effect these changes are pricing, RD&D, standards, incentives, restrictions, education, procurement, infrastructure development, and land-use planning. Some of these are available to state and local agencies. Many of these strategies intersect with other important social goals in making our urban centres vital, equitable and attractive places to live and work.

The second set of strategies would include measures such as integrated land-use and transport planning, which involves lifecycle cost accounting of the environmental impact of alternatives. This could reveal opportunities for different urban regions to avoid the proliferation of new roads and motor vehicles while still meeting the transport service needs of everyone. The most cost-effective options, from the standpoint of sustainable development, may involve:

- The development of dense urban growth corridors that are matched with corridors for mass transport development plans.
- Infrastructure improvements to encourage multi-modalism within and between urban centres so that people would have easy connections among different modes (for example, walking, bicycling and riding trains).
- Travel-demand management and demand-reduction strategies such as the subsidisation of mass transit use and car/van pooling.
- The enhancement of communications infrastructure to reduce the need for vehicle trips.

Bus Rapid Transit in Curitiba, Bogota, and elsewhere

Curitiba is one of Brazil's fastest growing cities, with over 2.1 million residents. In 1971, Jaimé Lerner, the then mayor, outlined an urban development philosophy that emphasised appropriate rather than high technology and urban innovation that was bottom-up rather than centralised, requiring citizens' participation rather than master planning. Two key objectives that emerged from this approach were: a) to give priority to public transport and b) to encourage growth along prescribed axial corridors to prevent concentric density variation and thereby avoid congestion near the city centre.

For over two decades, Curitiba's transport and land-use patterns have evolved incrementally. The city has shown how busways can deliver very high productivity, with 25,000 passengers an hour or more. The following elements were included:

- Express, exclusive busways with inter-district and feeder bus routes complementing express bus lanes along structural axes.
- Large bus terminals at the far ends of five express bus lanes for transfers. Medium-size terminals every 2 km.
- Single (social) fare, including transfers.
- Right-of-way for buses at intersections.
- Special raised boarding-tube bus stops, passengers pay in advance, speed boarding, two extra-wide doors.
- Double and triple-length articulated buses to increase capacity.
- Private bus companies (contracted on number of kilometres, not number of passengers).
- Land-use integration: zoning for high-density land use along structural axes, lower-density zoning away from access to public transport; information on land use widely available; historical building preservation is promoted by allowing potential transfer of rights to other areas; peer training on environment; government purchase of land for low-income housing 8 km away from city knowing that corridor would be developed there; bicycle paths and pedestrian areas.

Curitiba's experience with the concept of Bus Rapid Transit (BRT) was successfully replicated in Bogota and has now spread across the globe to cities in Asia, Australia, Europe, and North America. In India, there are plans to implement it in Ahmedabad, Delhi and Pune, and proposals are being studied in Bangalore and Chennai. While still not a silver bullet, its low costs (about 1-5% of conventional rail systems), high social and environmental benefits and potential synergies with a variety of environmental programmes involving recycling, parks and bicycle use have made Curitiba a touchstone for innovative transportation solutions in both developing and industrialised countries.

• The creation of safe pedestrian walkways and bicycle paths in combination with strict motor vehicle parking regulations in urban core regions, to make walking and cycling the preferred alternatives to driving.

The government has issued a National Urban Renewal Mission and a National Urban Transport Policy, both of which seem to be promising steps in the right direction. While mobility is still an explicit goal, there is also acknowledgement of the need to improve mass transit and integrate land-use planning with transportation. Unfortunately, the government reveals its bias towards capital-intensive and grand projects like metros rather than low-cost innovations like Bus Rapid Transit, even though a few demonstration BRT projects are included. And while there is a policy to promote non-motorised modes, there is also a requirement for the provision of parking spaces, which simply extends the 'automobilisation' of urban areas.

Furthermore, since some of these solutions are characterised by high investment costs and technical complexity, they need to be applied with care rather than as glitzy 'tech' fixes. The implementation of novel approaches can also be affected by the persistent adverse effects of past policies, perverse pricing, political recalcitrance and the absence of appropriate jurisdictional institutions. Overcoming all these barriers requires more than enlightened public policy at the highest levels, it also demands the creation of adequate financing facilities and a level playing field, and the development of transparent regulatory institutions and practices within the transport sector. Most of all, it needs a coherent planning framework and coordinated action at the municipal, state and national levels.

Some specific proposals to consider include:

• Creating the institutional and jurisdictional basis for a regional, transit-oriented urban growth planning authority.

• Establishing effective pricing mechanisms for transport systems to give the right price signals to users to internalise the external costs of transport use and also to generate adequate revenues for making investments in sustainable transportation.

• Making public investments (and inducing private investments) where feasible, for appropriate non-motorised infrastructure and Bus Rapid Transit.

• Establishing zoning regulations to encourage high-density urban growth and discourage car use where alternatives are available.

• Instituting regulations and standards for clean vehicles, technologies and multi-modal choice.

• Integrating transport policies with policies in other sectors such as telecommunications, to meet local and national sustainability goals.

• Creating public education programmes on sustainable transport and land use.

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Growth of population and motor vehicles in metropolitan cities

Major Cities	Population		Annual Growth Rate %	Vehicle Population		Annual Growth Rate %
	1991	2001	(1991-2001)	1991	2001	(1991-2001)
Mumbai	12,571,720	16,368,084	2.67	629,000	1,069,499	5.45
Kolkata	10,916,272	13,216,546	1.93	475,000	664,046	3.41
Delhi	8,375,188	12,791,458	4.33	1,813,000	3,876,407	7.90
Chennai	5,361,468	6,424,624	1.83	544,000	1,355,550	9.56
Hyderabad	4,280,261	5,533,640	2.60	443,000	950,624	7.93
Bangalore	4,086,548	5,686,844	3.36	577,000	1,680,278	11.28
Ahmedabad	3,297,655	4,519,278	3.20	374,000	899,346	9.17
Pune	2,485,014	3,755,252	4.22	280,000	658,313	8.92
Surat	1,517,076	2,811,466	6.36	197,000	575,373	11.31
Kanpur	2,111,284	2,690,486	2.45	169,000	384,955	8.58
Jaipur	1,514,425	2,324,319	4.38	266,000	693,336	10.05
Lucknow	1,642,134	2,266,933	3.28	216,000	555,773	9.91
Nagpur	1,661,409	2,122,965	2.48	167,000	458,961	10.64
Patna	1,098,572	1,707,429	4.51	180,000	312,801	5.68
Indore	1,104,065	1,639,044	4.03	214,000	550,388	9.91
Vadodara	1,115,265	1,492,398	2.96	162,000	506,014	12.06
Bhopal	1,063,662	1,454,830	3.18	130,000	333,482	9.88
Coimbatore	1,135,549	1,446,034	2.45	66,000	448,327	21.12
Ludhiana	1,012,062	1,395,053	3.26	202,000	645,686	12.32
Kochi	1,139,543	1,355,406	1.75	29,000	226,185	22.80
Visakhapatnam	1,051,918	1,329,472	2.37	142,000	208,779	3.93
Varanasi	1,026,467	1,211,749	1.67	112,000	338,715	11.70
Madurai	1,093,702	1,194,665	0.89	38,000	239,987	20.24

Source: 'Transportation in the 21st Century' by Ranjan K Bose, The New Energy Economy, *edited by G M Pillai, World Institute of Sustainable Energy*

Energy intensity by mode of transport

Mode of Transport	Occupancy (Persons/ Vehicle)	Fuel Type			
		Petrol	Diesel	CNG	Electricity
Passenger Modes: BTU/Passenger-km					
Scooter/motorcycle: 2-stroke	1.5	527	-	-	-
Scooter/motorcycle: 4-stroke	1.5	426	-	-	-
Autorickshaw: 2-stroke	1.75	938	-	-	-
Autorickshaw: 4-stroke	1.75	738	-	666	-
Car	2.5	1206	1302	971	-
Urban bus	50	-	197	311	-
Suburban electric rail	800	-	-	-	27
Main line rail	900	-	135	-	46
Freight Modes: BTU/Ton-km					
Truck	-	-	1587	-	-
Main line rail	-		256	-	85

Source: NTPC Report, Planning Commission, May 1980; Pricing and Infrastructure Costing for Supply and Distribution of CNG and ULSD to the Transport Sector in Mumbai, TERI, 2002. BTU=British Thermal Units

Climate's new trustees

Piggybacking on the goal of reducing carbon emissions, multilateral banks including the World Bank and Asian Development Bank are re-orienting their lending priorities. They are pushing big hydropower projects and nuclear power as feasible and economically viable for reducing carbon emissions in transition countries like India and China

RICHARD MAHAPATRA

FAR AWAY FROM THE CURRENT IMPASSE over the Sardar Sarovar dam project in India, in Washington, decision-makers at the World Bank (WB) are swiftly pushing for big hydropower projects. The World Bank is also talking about lending for nuclear power projects.

In the early-1990s, the Narmada Bachao Andolan (NBA) campaign against the WB-funded Sardar Sarovar Project forced the Bank to stop funding the project. Since then, the WB has been reluctant to lend for big projects.

Closer home, the Asian Development Bank (ADB), a regional multilateral development bank based in Manila, Philippines, is also seriously considering lending for high-risk big hydropower projects, and is also talking about lending for nuclear power projects.

The return of multilateral development banks to lending for big dam projects, and their reversal of the principle of not lending for nuclear power projects, piggybacks on the goal of reducing carbon emissions to mitigate climate change.

These banks are aggressively re-orienting their lending priorities to allow them to capture the multi-billion-dollar carbon market as well as increase lending in transition countries like India, China and Brazil. The WB and the ADB are trying hard to stay relevant in big borrower countries like India and China. And, given the enormous energy needs of these fast-growing economies, energy is turning out to be a priority sector for multilateral development banks. The threat of climate change only facilitates this process.

On April 23, in Washington, the Development Committee, a senior decision-making body of the World Bank, debated a confidential report titled 'Clean Energy and Development: Towards An Investment Framework'. This comprehensive report strongly advocates multilateral development banks lending for big hydropower projects and nuclear power, to help reduce carbon emissions. It also accepts nuclear energy as a viable clean energy source that needs to be encouraged. The report focuses on transition countries like India and China. The Development Committee has expressed satisfaction over the report and decided that by September this year it should be approved by the WB. Immediately after the deliberation, Katherine Sierra, vice-president for infrastructure at the WB said: "Nuclear is an option that some countries are pursuing as part of their overall energy mix. We felt it important to at least lay out the different options that people are employing. We think it's important to…provide incentives to go down the low carbon path, and have countries look at the options most suitable to their needs."

The report is a comprehensive and radical assertion of lending for big hydropower and nuclear projects as insurance against climate change. Although it claims that its suggestions are not WB-centric, it does point to the Bank's future lending areas.

The report, which was put together in consultation with officials from India, Brazil, China and South Africa, can safely be said to reflect the governments' priorities in lowering carbon emissions.

It suggests a 'fast two-track' approach to developing an investment framework for clean energy to reduce carbon emissions. Interestingly, despite the fact that developed countries are the biggest polluters, with the US alone contributing 25% of greenhouse gases, the report prescribes carbon reductions for developing countries. It sees developing countries as the place where most carbon reduction activities will have to take place. This can be interpreted as the World Bank seeking opportunities for lending (after all, developed countries don't borrow from the Bank).

At the summit of the Group of Eight (G8) most industrialised nations, in Gleneagles, Scotland, last July, the World Bank was asked to propose a plan for a global transition to a sustainable energy future that would support energy sector expansion towards the ultimate goals of economic growth and poverty reduction. The G8 gave the World Bank the mandate to "take a leadership role in creating a new framework for clean energy and development".

The World Bank has historically been the single largest financier of large dams worldwide, providing an average of around $ 1.25 billion a year for big dams over the past 60 years — five times more than current lending for clean, renewable energy. The report shows that 60% of the Bank's supposed support for renewable energy and energy efficiency (RE and EE) is, in fact, for big hydro projects.

In its annexure, the report details the carbon reduction activities of specific countries. For India, it says that the government is pushing for big hydro projects along with nuclear energy. The report's authors consulted extensively with Indian officials, including the energy ministry and the Planning Commission. India is the fifth largest emitter of carbon related to fossil fuels, after the US, China, Russia and Japan. It contributes 4.2% of

Multilateral development banks are in fact the largest financiers of carbon-emitting projects such as coal-fired power plants. The World Bank's energy financing for big fossil fuel projects during 2002-03 beat renewable and energy efficiency projects by a 17 to 1 ratio

the world's total carbon dioxide. Eighty per cent of India's electricity comes from thermal sources, thus making it one of the largest producers of greenhouse gases. The report is very specific in its prescription for India: "…opportunities to reduce the GHG intensity of the power sector (are) to shift the balance of production towards more diversified and cleaner sources. The latter include a mix of large and small hydro (projects)…"

The World Bank has already made clear its intention to lend for big projects in India; the confidential report carries this intention forward. The foray back into large dams in India comes close on the heels of the Bank's approval of an Infrastructure Action Plan (IAP) in July 2003. The plan aims to increase Bank support for what it terms "high risk/high reward" infrastructure projects such as large dams, over the next two years. As part of the IAP, the World Bank recently announced a doubling of its lending to India, predominantly for projects in the power, water and transport sectors.

Meanwhile, the ADB is going to review its energy policy adopted in 1995. According to a high-level official at the ADB: "We are not sure whether we will be lending for nuclear power projects, as currently we don't have any request for lending. But definitely this year we will be talking about it." The ADB is one of the World Bank's key partners in its clean energy development programme. "Nuclear power generation is a proven technology that provides about 20% of the world's electricity production. There is, however, widespread public concern about the safety of nuclear power operations and waste disposal methods," reads the energy policy. In its 1995 energy policy, the ADB states that based on concerns of transfer of nuclear technology, proliferation risks and environmental and safety aspects, the ADB would not support nuclear power. However, the 2000 review papers of the policy don't mention this.

Sources say that given requests from big borrowers like India and China, the ADB may consider starting a debate on it. Meanwhile, the ADB is now definitely open to lending for big hydropower projects. It has announced a $ 2 billion a year credit line for water-related projects; the World Bank had already done so in 2004. Both pitch for large centralised projects.

Of late, multilateral development banks like the World Bank and the ADB have become the new trustees of climate. Over the last five years, they have seriously pursued the carbon market. The World Bank coordinates all such activities; this latest report is one way of establishing its primacy in this field. Over the past five years, banks like the World Bank, the ADB, the African Development Bank, the European Bank for Reconstruction and Development, European Investment Bank and the Inter-American Development Bank have invested over $ 17 billion in projects that directly or indirectly contribute to lowering carbon emissions in developing countries.

Both the World Bank and the ADB now manage carbon funds worth close to $ 5 billion. The former is managing eight carbon funds as trustee, where various countries contribute. The ADB is managing four funds under its Renewable Energy, Energy Efficiency and Climate Change (REACH) programme.

The catch is that the International Energy Association estimates that a total capital investment of $ 8.1 trillion, equivalent to an average of $ 300 billion/year, is needed from 2003 to 2030 for developing and transitional economies to meet their energy needs. Of this, electricity comprises roughly 73%, oil 12%, natural gas 12% and coal 3%. Of the total global greenhouse gas emissions, the energy sector contributes 80%. Thus any carbon reduction programme has to focus on the energy sector.

The World Bank report says that mitigating greenhouse gas emissions would cost anything between $ 10 billion and $ 200 billion/year. This offers huge opportunities to lend and do business in the name of climate change mitigation. The focus on developing countries stems from the fact that developed countries with carbon emission commitments can't reduce emissions in their own countries. According to the World Bank, in developed countries the cost of reducing one tonne of carbon dioxide could cost between $ 15 and $ 100, while it would be around $ 1 to $ 4 in developing countries.

Contrary to their new role as trustees of climate change mitigation, multilateral development banks like the WB and the ADB are in fact the largest financiers of carbon-emitting projects such as coal-fired power plants. According to Greenpeace, an international campaign group, between 1970 and 2003, the ADB co-financed projects to the tune of US$ 40.6 billion, 41% of which was to the energy sector. Though the ADB's energy policy advocates renewable energy, only 1% of the eight energy sector projects receiving ADB funding of US$ 756.7 million in 2003 was any kind of clean energy development. The World Bank's energy financing for big fossil fuel projects during 2002-03 beat renewable and energy efficiency projects by a 17 to 1 ratio.

Hydropower is hot property again

Hydropower is riding the wave of climate change: it is touted to cut down the use of fossil fuels and sequester carbon in its reservoirs. The pace of implementation is being stepped up in India, with a planned 162 projects in 16 states by 2017. But claims of the climate benefits of hydropower seem to be running far ahead of the science of the matter

SHRIPAD DHARMADHIKARY

"I AM GIVEN TO UNDERSTAND that a turnaround in hydropower project execution is in the offing." These words by then Prime Minister Atal Behari Vajpayee at the inauguration of the ambitious 50,000 MW hydroelectric initiative of the Government of India neatly capture the new excitement surrounding hydropower. The pace of implementation seems to have increased. While the last 20 years saw an addition of 13,666 MW of hydro capacity in India, the five years of the Tenth Plan period alone are expected to add about 11,000 MW. The World Bank, which had practically stopped funding large dams, has explicitly expressed its intention to do so again. The government is planning a series of sops to push hydropower. And there is an aggressive promotion of hydropower at conferences and seminars as well.

Hydropower has for long been the special headache of planners and implementers in the country. India is reportedly endowed with enormous economically exploitable hydro potential, assessed at about 84,000 MW at 60% load factor (148,700 MW installed capacity). Only around 18% of this had been harnessed till 2002. The sharply falling share of hydro in total capacity — from 46% in the 1970s to about 25% today — is also cited as a serious problem. Opposition to large dams has been identified as a key factor.

Opposition to large dams is not new. Among the first such organised struggles was the satyagraha against the Mulshi hydroelectric project of the Tatas led by Senapati Bapat in the early- and mid-1920s. In the last couple of decades, this opposition has been stepped up, both in breadth and depth, not just in India but globally.

The net result was a sharp fall in funding for large dams from the World Bank and other such institutions. Whereas the World Bank financed 3.5% of dams constructed in the 1970s, this fell to less than 1% in the 1990s. The number of dams being built worldwide every year also declined. This difficulty in proceeding with dam-building is what led to the initiation of, as well as industry support to, the World Commission on Dams (WCD).

The WCD with 12 members representing dam-builders, engineering companies, NGOs, affected people's movements, etc, was set up in 1998 and produced a unanimous report in November 2000. The WCD findings vindicated most of the major criticisms made by those challenging large dams.

Post-WCD, there seems to have been a clear hardening of will and a newfound determination to push large dams. The old arguments are being reiterated, all serious concerns are being swept aside, regulatory mechanisms and social and environmental requirements are being diluted, and there's an increased use of force.

Climate change is a major global concern right now. The push for hydropower clearly attempts to ride this wave. For example, the International Hydropower Association, in one of its pamphlets, says that hydropower helps fight climate change. It is supposed to be doing this not only by substituting and hence cutting down the use of fossil fuels, but also by sequestering carbon in its reservoirs that would act as carbon sinks.

But the role of hydro in mitigating climate change is far from settled. This is what the WCD report says on the issue: "A first estimate suggests that the gross emissions from reservoirs may account for between 1% and 28% of the global warming potential of GHG (greenhouse gas) emissions. This challenges the conventional wisdom that hydropower produces only positive atmospheric effects… In some circumstances the gross emissions can be considerable, and possibly greater than the thermal alternatives."

A report prepared by an atmospheric scientist for the International Rivers Network also questions the carbon sequestering impact of reservoirs, saying that this may be a limited, sometimes temporary, benefit. In some cases the net impact of a reservoir could be negative when its own GHG emissions are more that its sequestering capacity. It also cautions that a "large amount of further research is needed to come up with any reliable estimates of the full climate impacts of reservoir construction". Thus, the claims of the climate change benefits of hydropower seem to be running far ahead of the science of the matter.

On the other hand, an increased dependence on large hydro projects could well mean increased vulnerability. Most dams are built on the assumption that the hydrology of the river will remain what it was in the past. Extreme events resulting from climate change could threaten dam safety (in case of extreme floods) and performance (drop in power output due to drought, a well-known problem even today). This would be even more of a concern in snow-melt-dependent river basins, where much of India's new hydropower potential is.

Another argument in favour of hydropower is that it saves precious fossil fuel, an issue all the more important in the context of galloping oil prices in the international market.

Hydro also cuts down on the pollution associated with the burning of fuels. But if hydro cuts down on fossil fuels, it does so at the expense of other impacts on the ecosystem and on communities. So it may be 'cleaner' in some respects, but 'dirtier' in others.

Indeed, the comparison of fossil fuel sources and hydropower is a false choice. In the longer term, the only real choice is between high-impact sources (including large hydro, fossil fuels and nuclear energy), and low-impact sources like renewables. Unfortunately, in spite of all the debates, little more than lip service is paid to the development of renewable sources of energy.

Some other justifications

Some new, rather innovative reasons are also being advocated to push for hydropower. The World Bank in its recent report entitled 'Turbulent Waters' on India's water sector says: "Whereas arid rich countries (such as the United States and Australia) have built over 5,000 cubic metres of water storage per capita, and middle-income countries like South Africa, Mexico, Morocco and China can store about 1,000 cubic metres per capita, India's dams can store only 200 cubic metres per person." This implication that somehow per capita storage capacity is a measure of development borders on the absurd. Take Ghana that had a capacity of 153 BCM from just the Akosombo dam in 1965. This worked out to a per capita storage of 18,000 cubic metres. Was Ghana in 1965 (or even today) so prosperous?

The same report says that "the Himalayan hydropower sites are, from a social and environmental perspective, among the most benign in the world". As anyone who is following Himalayan dams like Tehri or Nathpa Jhakri, to name just two, would understand, this is a laughable assertion. But it is a cleverly made statement, as large numbers of new dams in the country are being planned in the Himalayas.

In fact, there are serious questions about the performance of hydro projects. A study by Himanshu Thakkar points out that while the installed hydro capacity in the country went up from 21,000 MW in 1994-95 to 31,000 MW in 2004-05, the electricity generated per installed megawatt has actually gone down sharply from 3.97 MU/MW to 2.74. And this is not due to rainfall deficiency. These and other serious performance issues are being ignored.

It's all about money

The Tenth Plan envisaged an outlay of Rs 43,000 crore for hydropower alone in the central sector. The ambitious initiative proposes an installed capacity of about 50,000 MW through 162 projects in 16 states by 2017 (about half of this capacity is in Arunachal Pradesh). At Rs 6 crore per MW, this will involve around Rs 300,000 crore over the next 10 years. All this adds up to huge contracts, consultancies, commissions, and glorious visions of wealth through power generation. A recent cabinet note by the Arunachal Pradesh government paints a picture of "the state floating in hydro-dollars like the Arab countries are floating in petro-dollars".

It is not surprising then that all sorts of justifications based on half-truths are being made to push big dams and dilute their social and environmental impact.

Thus, mandatory environmental hearings have turned into farces. Environmental Impact Assessments are not worth the paper they are written on. People are just being pushed out without proper rehabilitation. Cash compensation is being forced on people instead of a land-for-land policy for resettlement. And sops are being planned to encourage the private sector to take up hydropower projects.

The fact is that there are many and serious problems with large dams, and they won't go away. Neither will the controversies and the protests. Attempts to browbeat people into submission and to manufacture consent and public opinion in favour of big dams are not likely to work.

Who will drive development?

So what happens to India's great leap forward? Where will the power come to drive the expected 8-9% growth in the economy? There are no easy answers. Indeed, the fundamental question here is whether it is ethical and possible that this 8-9% growth can be achieved at the cost of a section of society. That is exactly how the new resurgence in hydropower is being pushed. It promises to generate electricity but uproot communities, destroy livelihoods, devastate river ecosystems on which millions depend, and, of course, cost billions of rupees. This should be unacceptable in any civilised society, and it will be unacceptable in India.

The real solution to India's energy needs can come only when we realise that 1) there are no unlimited sources of energy, so we will have to, at some time, consider limits on consumption; 2) any energy source will have an impact on the environment, so we need to actively develop low-impact sources; 3) no solution can work over the long term if it is at the cost of one section of society, so we need to make the decision-making process transparent and participatory and make sure that those affected have first claim on the benefits generated by projects and programmes.

That will be the real resurgence.

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A trading system based on hot air

Smoke and mirrors defines the world's newest commodities trading system, one in which India is a pivotal participant. In the name of sustainable development, Indian industry is claiming revenue through Clean Development Mechanisms, a key device of the Kyoto Protocol. This reliance upon the market to clean up the mess represents an increasingly prevalent paradigm in India's response to climate change

RAHUL GOSWAMI

WE NEED TO REVISIT, critically, the idea that any dialogue, discussion, agreement or process that has anything to do with the Kyoto Protocol is necessarily going to benefit developing India, and indeed the developing South. The laborious international palaver concerning climate change, the impenetrably dense thickets of national agencies and multilateral organisations, sundry United Nations bodies and all manner of private sector carpetbaggers exist, for the most part, to obscure one truth only: that is to ensure that very little changes for Globalisation Inc.

There are several ways of seeing the problem here, and it is a sign of our times that a view that should be Indian, Southern, is, in fact, scarcely so. For, just as the development dialogue has been appropriated by the opponents of people-centred and socially-just development, so has this debate been skewed by the imposition of a grammar that has no genesis in our communities.

Like all environmental issues, the climate crisis is a political issue too. Within a limited science, it revolves around both the overuse and the skewed use of the earth's capacity to keep greenhouse gas proportions in the atmosphere within a certain range.

In the simplest of terms, the earth's carbon dioxide dump is overflowing. Industrial societies have long been extracting and then transferring carbon from underground deposits of coal and oil to the air. As a result, the percentage of greenhouse gases in the atmosphere is increasing every year. That what we call the industrialised North has been using its share of resources (fossil fuels and otherwise) inequitably, and abusing the capacity of the earth to absorb such punishment, is well-known now, and the example of a country like the United States being responsible for a quarter of greenhouse gas emissions has become part of environmental catechism.

From a purely ecological economics point of view, it would appear that the commonsense solution is both to reduce use of the earth's greenhouse gas dump overall and to divide up the dump more equitably. The 1997 Kyoto Protocol is alleged to tackle these twin objectives. It requires the industrialised North to start cutting emissions first — to about 5% lower than 1990 levels by 2008-2012 — while for the present leaving the South alone. (Shifts in the balance of global economic power and resource use have changed the landscape considerably since the Protocol was first drafted, but that polemic is outside the scope of this discussion.)

Among the Kyoto 'mechanisms', as they are called, that are designed to deliver these objectives is the Clean Development Mechanism (CDM), an aspect that I studied during the course of a Panos-directed and funded programme to examine the Protocol and energy policy in South Asia. In logic, the CDM is neither fish nor fowl, although neither the absence of definition nor clarity of purpose has prevented it from catalysing the creation of an entirely new commodity — notional absence of carbon. I will return to this free market sophistry later.

This creation has arrived in India at a time when the stock markets are exuberant, when the popular belief in the country's economic strength is at a high pitch, when corporate India is aggressively expansionist, and when concepts such as corporate social responsibility have become fodder for public relations mills. It is a fertile landscape for a concept that, in fact, seeks to establish a trading system based on hot air.

In optimistic theory, the CDM is envisaged to function as follows:

- A polluter country from the North (obliged to reduce its emissions in order to meet its targets) can rely on a project that takes place in a developing country (that has no target to reach) and claim the credit from doing so. For the polluter country, it would usually be cheaper to invest in the reduction of emissions in developing countries than by domestic action.

- The process envisages the value of technology in reducing emissions, the value to the developing country of cleaner and newer technology, and the use of market forces to keep the costs of reducing emissions down. Enforceable targets are expected to help create "a lively and productive market" (a quote from one enthusiastic technology-transfer broker) in carbon reduction credits, or Certified Emissions Reductions (CERs) units.

- This involves the original idea of using global governance negotiated in the final Kyoto Protocol texts along with market forces to reduce greenhouse gases (GHGs), which, after all, is a worldwide problem, while at the same time avoiding mere control and command to enforce compliance. Since markets are inclined to find the least-cost alternatives — so the brokers, traders and multilateral funding institutions would have us believe — the "market could take off and spiral the costs of emissions reductions downwards".

There is a seductive *déjà vu* at work here, one that recalls the controversies of power sector deregulation. Consider this argument: "Central to the paradigm of power liberalisation is the belief that electricity should be treated as a private commodity rather than as a public service. Advocates suggest that it would create conditions for 'self-regulating' markets, which would automatically determine optimal supply-demand levels as well as optimal prices" ('Towards Equitable, Sustainable, and Democratic Electricity Policies'; Transnational Institute briefing, 2002).

In the power sector, liberalisation (used interchangeably with 'deregulation') has resulted in the creation of electricity oligarchies, which tend to be dominated by powerful transnational corporations. Moreover, power liberalisation simply attempts to impose a market logic onto the centralised technical structure of the electricity system without actually transforming it such that it becomes compatible with decentralised market activities. The promise of economic efficiency as a by-product of liberalisation in the power sector has not addressed existing socio-political and environmental problems. Instead, new challenges have been created in the meeting of equity and sustainability goals.

In India, the actors promoting the CDM are employing an eerily similar vocabulary. "The Indian government has a proactive position on CDM, so that India is the biggest player in the CDM area with the largest number of projects presented to date," is an opinion presented in personal communication with an executive officer of a carbon trading consultancy. "In our opinion, India has not set excessively stringent sustainable development goals in order to impede CDM project development."

Therein lies the nub of an alarming consideration. For, Indian industry is a frontrunner in a market that is fast evolving, and with moves afoot to extend the European emissions trading scheme beyond 2012 (when the Kyoto Protocol in its present form expires). Indian firms are likely to capture more than 10% of the global trade. Data made available in November 2005 by the Ministry of Environment and Forests' National CDM Authority shows that India is overwhelmingly dominant in the Asia-Pacific region in terms of number of CDM projects, which are designed to reduce emissions of greenhouse gases that contribute to global warming (see box).

In India, the CDM is rhetorically mandated to assist in achieving

sustainable development. However, neither the CDM's architecture nor practice within industry appears able to internalise this objective. For all the politically correct intentions made public about sustainable development, CDM projects generate revenues by reducing or storing a quantity of greenhouse gas emissions which are commodified as carbon credits and sold. The various co-benefits that these projects may create are not commodified and do not directly produce revenues through the CDM.

Arguably, the CDM's project-based structure makes it almost impossible for the broader sectoral or national benefits provided by a renewables project to be rewarded because they are so difficult to quantify on a project level. Judging how many tonnes of a specified greenhouse gas have been reduced or stored by an individual project in a delineated project boundary — as compared to a theorised business-as-usual scenario — is complex enough. Yet, quantifying and commodifying the additional benefits that a renewables project provides outside that boundary would be extremely difficult and prohibitively expensive for each individual project. Which is why these are not addressed, despite the apparently impressive strata of national regulation and authority, the claim of industry self-regulation, the scrutiny of certification agencies and validation authorities. Perversely, and perhaps more worryingly, the project-based structure also fails to penalise negative impacts outside the project boundary and can reward projects that, while delivering cheap carbon credits, undermine the broader goal of climate protection and sustainable development.

At the same time, in India as elsewhere, there has been an explosion in numerous types of carbon market financial services in brokerage, project development, consultancy, procurement, online trading, financial journalism, event planning, project financing and so on. The branding is a smooth mix of cyber-environmental and financial language, and helps the formation of post-industrial names like CO2e.com, Eyeforenergy, Natsource and Ecosecurities. There are also more active and advanced international trading associations, stakeholder dialogue fora and consortia to conceptualise the way exchanges may work in the future.

Has this imposing array of expertise been able to help balance the equation in the national interest? It would appear not, and a critical gap has to do with the very structure of the CDM, which turns into a tradable commodity (notional savings of greenhouse gas emissions) what we really have no means to measure. It is, in many ways, a web of interconnected systems with, at its focus, nothing more than smoke and artfully arranged mirrors.

India, through industry rather than development policy, demonstrates a vague commitment to climate action, with the inherent problems relating to carbon 'offsets' and emissions trading being swept aside by a firm belief in the market. The problem of climate justice then requires not a radical rethink about fuel sources and their use, about social and community imperatives, but the 'invisible hand' of the market to sweep up the mess in the most cost-effective manner possible. Part Dalal Street economics and part business process outsourcing, this reliance upon the market represents an increasingly prevalent paradigm in India's response to climate change.

The 'win-win' rhetoric pervading the climate discourse is both an attempt to confound and marginalise those seeking more meaningful and effective action on climate change, as well as contribute to increased corporate power and further commodification of natural resources such as the earth's carbon-cycling capacity. The neoliberal ethic embodied in power blocs such as the G8, themselves highly dependent on the fossil fuel economy, is ultimately what drives this agenda forward. Free-market environmentalism and increased trade and investment liberalisation in the area of 'environmental

161 of 232 CDM projects in the Asia-Pacific are in India

India accounts for 161 of the Asia-Pacific region's 232 projects "in the pipeline". The 134 projects cleared so far amount to an investment of over Rs 10,000 crore in technologies and systems designed to reduce fossil fuel use, increase efficiencies of industrial processes and switch from fossil fuels to renewable sources of energy like biomass. It is a big market and is growing rapidly. Analysts have forecast the size of the future global greenhouse gas market to range from US$ 10 billion to US$ 1 trillion by 2010. Significant trading activity is already underway with dedicated 'carbon exchanges' — such as the Chicago Climate Exchange and the Asia Carbon Exchange — having been established.

That much of this trading has taken place well ahead of legislation indicates the speed at which industry is seizing the opportunity. Hundreds of trades have been completed in the international markets, corresponding to approximately 250 million tCO_2eq (tonnes of CO_2 equivalent).

CDM projects set up by Indian industry are expected to generate over 155 million Certified Emissions Reductions (CERs) until 2012, based on projects that were approved by Indian authorities until November 2005. Of these, CERs generated by 'industrial process' methodologies are in the forefront and account for about half the expected output. Other key methodologies are energy efficiency and fuel switching.

Several Indian companies that are implementing CDM projects are thought to have agreements to deliver CERs at various stages during the 2008-2012 period, for around □ 15/CER (US$ 17.5 at current rates). Karnataka, Andhra Pradesh, Rajasthan and Tamil Nadu have emerged as the most active host states in the country. Indeed, a unit in Rajasthan, SRF Ltd, is to deliver 500,000 CERs to Shell Trading International by April 2007. This agreement, approved by India's CDM authority, is amongst the largest committed to by an Indian company to date. SRF Ltd is the biggest nylon tyre cord fabric producer in the country and the eighth largest in the world.

goods' and 'ecosystem services' is ultimately a false promise. For activists seeking to engender meaningful social and environmental change in the climate arena, these trends must be challenged outright.

"The main problem with the CDM is the problem of determining the baseline emissions that would otherwise have occurred, as well as the amount of administrative cost involved in having CDM projects evaluated and approved," states a policy study on India and climate change. "Probably the most attractive aspects of the CDM approach is the application to changes in land-use practice and afforestation of degraded areas. However, India is already spending resources on reforestation independently of the CDM mechanism and it may be unclear what is additional to baseline," (*Climate Change Policy for India*, by Warwick J McKibbin, The Lowy Institute for International Policy, Sydney; Centre for Applied Macroeconomic Analysis, ANU, Canberra; and The Brookings Institution, Washington DC).

While industry is certainly attracting a substantial share of criticism for railroading through its ideas about sustainable development via the lens of climate change, India's national authority — the Ministry of Environment and Forests' National CDM Authority — is for its part no honest broker. Even so, the CDM landscape in India is akin to that which obtains elsewhere. The United Nations Framework Convention on Climate Change (UNFCCC) and national governments caught up in the spirit of deregulation (or rather, corporate-friendly re-regulation) have been reluctant to develop uncompromising rules for the use of market-based mechanisms in the Kyoto Protocol.

In the absence of unambiguous coda and strict enforcement mechanisms, business has been largely left to its own devices and, in many cases, actively encouraged to develop the rules of the marketplace as it sees fit. This *laissez-faire* approach makes it easier for corporations to influence the pace and development of these markets. When norms and standards are established — as is the case in India — it will be much more difficult for governments to intervene in the markets, assuming of course that there is such an intent at all.

A collective statement written in October 2004 by several research groups worldwide says carbon trading is designed to "... allow big fossil fuel users to delay reductions by buying their way out of trouble or by building new dumps (such as tree plantations) to park their carbon in temporarily. 'Giving carbon a price' will not prove to be any more effective, democratic or conducive to human welfare than giving genes, forests, biodiversity or clean rivers a price. There is no point in governments, export credit agencies, corporations and international financial institutions constructing a carbon market with one hand while, with the other, continuing to finance fossil fuel developments and forest destruction and dedicating only token sums to renewable energy".

The problem is a hydra-headed one. The planner or government bureaucrat in the South insists that he has the sole right to decide how to process nature or human labour, since he alone has access to modern science. In addition, he claims to act in the national interest. Since science is efficient and resources are scarce, only modern industry should be permitted to produce goods: both natural and older technological forms are inefficient, backward or slow. So runs the wisdom.

The definition of efficiency is, of course, arbitrary. The legitimisation of industry's rights over the rights of other processors has been adjudicated not by an impartial authority, but by powerful interests supported by an equally biased (often dreadfully mis- and under-informed) state power. Industrial processing has merely been assumed to be superior. Such unexamined assumptions can act as superstitions, generating in their wake an entire chain of painful consequences.

Paralysing superstition indeed is the leitmotif of the technocratic response to a matter as staggeringly complex as climate change. The reigning superstition is the one that assumes a degree of measurability in any of the innumerable variables that govern such a concept. Forests, for example, which were till the other day thought to be carbon sinks are now viewed with suspicion as methane factories. Deep ocean currents yield through their meanderings no secrets to inquisitive instruments. Now a carbon numerocracy seeks, pathetically, to define the myriad fluid contours of our world. It would be laughable, a grand jest, were it not for the uncomfortable realisation that this post-modern operetta is being written into the balance sheets of biscuit factories and gasket manufacturers.

What lies ahead? For our rural and urban communities in whose names such sophistry is being practised as technologically-sanctioned sustainable development? For industries that are already hiring glib accountants versed in the metre and rhythm of the world's newest tradable commodity? For our planners, struggling to balance development cant against economic catechism and harried all the while by the clinical formulae of multilateral lending agencies?

India is a party to the climate convention and must demand and design a mechanism within the Kyoto framework (or the new, six-country Asia-Pacific Partnership on Clean Development) that promotes sustainable development in the South and which delivers targeted technology transfer, not supports a technology-neutral commodities market. Its insistence must be on the promotion of projects that — according to more parameters than just the technocratic — contribute to sustainable development, such as renewables. More important still is to address the context in which such a mechanism will function. If it operates within a policy perversity that forces co-existence of a Kyoto Protocol and the CDM alongside massive North-South financial flows to fossil fuels, it will fail. A real Indian solution to climate change and sustainable development must divert these flows, not underwrite carbon markets alongside them.

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Flaws in the pro-nuclear argument

Flailing nuclear establishments worldwide are using global warming as an opportunity to resurrect an industry that has collapsed because of its inability to provide clean, safe, or cheap electricity. India too is forging ahead. Thousands of crores of investment later, just 3% of India's installed electricity-generation capacity comes from nuclear energy

M V RAMANA
SUCHITRA J Y

And it is worthy of note that the systems which the Europeans have discarded are the systems in vogue among us. Their learned men continually make changes. We ignorantly adhere to their cast-off systems.

— Mahatma Gandhi, *Hind Swaraj*

NUCLEAR POWER is in the news these days in a new incarnation — as an environmentally sustainable source of electricity. For example, the recent 'Declaration by India and France on the Development of Nuclear Energy for Peaceful Purposes', signed in February 2006, begins with the "recognition" that "nuclear energy provides a safe, environment-friendly and sustainable source of energy". The sheer audaciousness of terming a technology that was responsible for perhaps the most destructive industrial accident ever — the Chernobyl explosion of April 1986 — safe, cannot but cast doubt on the rest of those contentions. And yet, by being repeated time and again, such claims do begin to resonate with the public and gain acceptance. It is therefore necessary to look beyond the glossy exterior and analyse why nuclear power is not sustainable. As we argue below, it is neither environment-friendly, nor safe, nor economical.

This new incarnation of nuclear energy has arisen in the context of increasing global warming. Pro-nuclear advocates have offered nuclear power as a solution to global warming, and given the gravity of the likely impact of impending climate change, it is not surprising that many have started looking at it more favourably. Flailing nuclear establishments around the world have grabbed this second opportunity and made claims for massive state investments, in the hope of resurrecting an industry that has collapsed in country after country due to its inability to provide clean, safe, or cheap electricity.

Two implicit but flawed assumptions underlie such claims about the significance of nuclear energy in controlling climate change. The first is that climate change can be tackled without confronting and changing Western, especially American, patterns of energy consumption — the primary causes and continuing drivers of unsustainable increases in carbon emissions and global warming. This is impossible; global warming cannot be stopped without significant reductions in the current energy consumption levels of Western/developed countries. Efforts by various developing countries, especially by elites within such countries, to match these consumption levels only intensify the problem.

The second is that the adoption of nuclear power makes sense as a strategy to lower aggregate carbon emissions. A good example is Japan, a strongly pro-nuclear energy country. As Japanese nuclear chemist and winner of the 1997 Right Livelihood Award, Jinzaburo Takagi showed, from 1965 to 1995, Japan's nuclear plant capacity went from zero to over 40,000 MW. During the same period, carbon dioxide emissions went up from about 400 million tonnes to about 1,200 million tonnes. In other words, increased use of nuclear power did not really reduce Japan's emission levels. The massive expansion of nuclear energy, then, was not motivated by a desire to reduce emissions. If indeed Japan were sincere about doing that, it would have adopted very different strategies.

There are two reasons why increased use of nuclear power does not necessarily lower carbon emissions. First, nuclear energy is best suited only to produce baseload electricity, which only constitutes a fraction of all sources of carbon emissions. Other sectors of the economy where carbon dioxide and other greenhouse gases are emitted, such as transportation, cannot be operated using electricity from nuclear reactors. This situation is unlikely to change anytime soon.

A second and more fundamental reason is provided by John Byrnes of the University of Delaware's Centre for Energy and Environmental Policy, who observes that nuclear technology is an expensive source of energy and can be economically viable only in a society that relies on increasing levels of energy use. Nuclear power tends to require and promote a supply-oriented energy policy, and an energy-intensive pattern of development, and thus, in fact, indirectly adds to the problem of global warming.

Though not motivated by such radical and far-reaching analysis, even mainstream environmentalists recognise that building new nuclear plants is not an answer to tackling climate change. For instance, a major 2006 report by the United Kingdom (UK) government's Sustainable Development Commission (SDC) concludes that doubling nuclear capacity in Great Britain would have only a small impact on reducing carbon emissions by 2035. In addition, the report identifies the following five major disadvantages to nuclear power:

- No safe long-term solution to the problem of radioactive waste from nuclear plants is available, let alone acceptable to the general public.
- The economic costs of nuclear power are uncertain but much

higher than those of alternative sources of generating electricity.

- Nuclear energy requires and will lock the country into a centralised distribution system for many decades, and hinder the development of distributed energy-generation technologies that are rapidly emerging as important sources of electricity.
- The signal offered by nuclear programmes that what is needed to tackle climate change is just a major technological fix undermines energy efficiency imperatives.
- There are several safety and security risks associated with nuclear proliferation.

All of these factors are just as relevant in India as in the UK; to these one might add some more based on our own atomic history. Let us take a closer look at the Indian atomic energy programme, which will illustrate or adumbrate some of the points made by the UK Sustainable Development Commission.

India's nuclear establishment: Promising much, delivering little

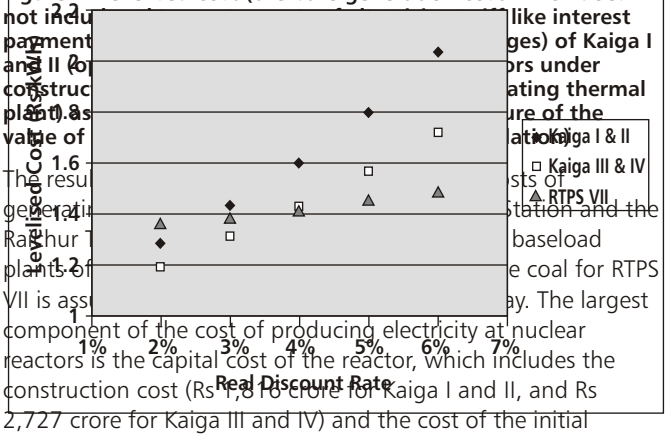
The Indian nuclear establishment, like similar institutions elsewhere but only more dramatically so, has historically promised much and delivered little. Since its inception, the Department of Atomic Energy (DAE) has been promoting nuclear power as the answer to our energy needs. According to the DAE's predictions, by 2000 there should have been 43,500 MW of nuclear-generation capacity in the country, while what has been realised even now is only 3,310 MW, less than 3% of the installed electricity-generation capacity. Even by the DAE's projections, this will not become a significant fraction of India's electricity for the next few decades.

Such continued failures are not because of lack of resources. Practically all governments have favoured nuclear energy and the DAE budgets have always been high — a trend that has intensified after the 1998 nuclear weapons tests. According to the Union expenditure budgets, the DAE's budget estimate has increased from Rs 1836.53 crore in 1997-98 to Rs 5505.08 crore in 2006-07, ie, it has more than doubled even in real terms.

The high allocations for the DAE come at the cost of promoting other more sustainable sources of power. In 2002-03, for example, the DAE was allocated Rs 3351.69 crore, dwarfing, in comparison, the Rs 473.56 crore allocated to the Ministry of Non-conventional Energy Sources (MNES), which is in charge of developing solar, wind, small hydro and biomass-based power. Despite the smaller allocations, installed capacity of these sources was 4,800 MW (as compared to 3,310 MW of nuclear energy). While their contribution to actual electricity generated would be smaller since these are intermittent sources of power, they have much lower maintenance costs. Further, most of these power programmes, like wind, began in earnest only in the last decade or two, and there is ample scope for improvement. This relative lack of attention to renewable and decentralised systems of electricity generation illustrates the third point highlighted by the UK SDC.

The experience with India's nuclear programme also exemplifies the UK SDC's argument regarding the economics of nuclear power. A comparison of the costs of generating electricity from nuclear and coal-fired thermal power plants, using the standard discounted cash flow methodology, shows that nuclear power is competitive only for low discount rates (see Figure 1); for a wide range of realistic parameters it is significantly more expensive. The discount rate is a measure of the value of capital, and given multiple demands on capital for infrastructural projects, including for electricity generation, such low discount rates are not realistic. A larger proportion of nuclear capacity therefore implies that poorer sections of society cannot afford electricity, at least without greater subsidies. It also implies that there are many far cheaper ways of reducing carbon emissions.

Figure 1: Levelised cost (the bare generation cost which does not include [illegible] like interest payment[illegible]ges) of Kaiga I and II [illegible]rs under construc[illegible]ating thermal plant[illegible]ure of the value of [illegible]ation)



The resu[illegible]sts of gene[illegible]station and the Ratnahur T[illegible] baseload plants of[illegible]e coal for RTPS VII is ass[illegible]ay. The largest component of the cost of producing electricity at nuclear reactors is the capital cost of the reactor, which includes the construction cost (Rs 1,818 crore for Kaiga I and II, and Rs 2,727 crore for Kaiga III and IV) and the cost of the initial loading of uranium fuel and heavy water used in the reactor. The corresponding capital cost in the case of RTPS VII is Rs 491 crore. (The capital costs mentioned do not include the interest during construction.)

This economic comparison is largely based on assumptions favourable to nuclear power. In particular, the calculated cost of coal-generated electricity internalises the cost of disposing flyash in an environmentally responsible fashion, but the nuclear costs do not include those of dealing with radioactive waste.

There is no credible solution to the problem of radioactive waste; the best that can be done is short-term management. The DAE treats spent nuclear fuel by reprocessing it and segregating the waste into different categories on the basis of their radioactivity. Reprocessing also allows the separation of plutonium, which, with further treatment, can be used as fuel in breeder reactors. Reprocessing, however, is expensive. Based on a careful examination of the budgets of the DAE, we estimate that the cost of reprocessing each kilogram of spent fuel from the DAE's heavy water reactors is in the range of Rs 20,000-30,000. The Nuclear Power Corporation does not include this cost in its tariff estimates; if included, it would increase the unit cost by Rs 0.40 to 0.60.

Besides the economic cost, the waste stays radioactive for tens of thousands of years, posing a potential health and environmental hazard to thousands of future generations. This is clearly iniquitous since these generations would bear the consequences while we use the electricity generated by these

reactors. Ethical dilemmas aside, no technology that generates such long-lived radioactive waste can be considered environmentally sustainable.

Further, different stages of the nuclear fuel chain release large quantities of radioactive and other toxic materials into the biosphere. Thus, the claims of nuclear energy being environment-friendly are absolutely baseless. The nuclear fuel cycle is polluting, albeit in a different way from coal power. Climate change may be a grave danger confronting us, but it should not blind us to other environmental hazards.

There is some evidence within our country of the adverse impact of such pollution. In the early-1990s, a scientific study on the health of the local population around the Rajasthan Atomic Power Station (RAPS) located at Rawatbhata near Kota observed statistically significant increases in, *inter alia*, the rates of congenital deformities, spontaneous abortions, stillbirth and one-day deaths of newborn babies, and solid tumours. Some of the data is summarised in Table 1. Similar problems have been seen in the uranium mining area of Jadugoda in Jharkhand.

These environmental and public health impacts result merely from routine radioactive releases from the nuclear fuel chain. Much worse could result from the catastrophic accidents that nuclear reactors and other (non-reactor) facilities are uniquely susceptible to. Chernobyl, the best-known instance of such a disaster, not only resulted in several thousand deaths but also contaminated thousands of square kilometres of land with radioactive elements like Cesium-137. Agriculture had to be suspended, over 100,000 people had to be relocated, and the economy of Belarus was devastated. In 1957, a tank containing radioactive waste from the Mayak reprocessing plant in the erstwhile Soviet Union exploded and contaminated 20,000 square kilometres. India, still a largely agriculture-dependent economy, can simply not afford the risk of such a disaster.

Table 1: Incidents of deformities, stillbirth and abortions

Deformities	**Proximate villages**	**Distant villages**
Total population	50	14
Above 18 years	5	4
Below 18 years	45	10
Below 11 years	38	6
Below 2 years (live born)	16	3
Stillborn children and abortions in the two years prior to the survey		
With deformities	4	0
Without deformities	2	0
Abortions	27	5

Note: Proximate villages are those near the Rajasthan Atomic Power Station (RAPS)
Source: Anumukti *Volume 6, Number 5, April/May 1993*

It is often stated that safety issues have been adequately addressed after the Chernobyl accident. However, the basic features of a nuclear reactor remain the same. It is a complex technology involving large quantities of radioactive material where events can spin out of control in a very short time. In studying the safety of nuclear reactors and other hazardous technologies, sociologists and organisation theorists have come to the pessimistic conclusion that serious accidents are inevitable with such complex high-technology systems. The character of these systems makes accidents a 'normal' part of their operation, regardless of the intent of their operators and other authorities. In such technologies, many major accidents have seemingly insignificant origins. Because of the complexities involved, all possible accident modes cannot be predicted and operator errors are comprehensible only in hindsight. Adding redundant safety mechanisms only increases the complexity of the system allowing for unexpected interactions between sub-systems and increasing new accident modes. All of this means that there is no way to ensure that reactors and other nuclear

facilities will not have major accidents.

There is an experiential basis for concern about such accidents within India. Practically all the nuclear reactors and other facilities associated with the nuclear fuel cycle operated by the DAE have witnessed accidents of varying severity. A few examples are the unexplained power surge at the Kakrapar reactor in 2004, the 1993 fire at Narora, and the collapse of the containment at Kaiga in 1994. Because of the reasons mentioned above, many of these accidents could well have become the basis for a major radioactive release.

A further source of concern is the fact that the Atomic Energy Regulatory Board (AERB), which is supposed to oversee the safe operation of all civilian nuclear facilities, is not independent of the DAE. Further, as Dr Gopalakrishnan, the former chairman of the AERB has observed, "the AERB has very few qualified staff of its own, and about 95% of the technical personnel in AERB safety committees are officials of the DAE, whose services are made available on a case-to-case basis for conducting the reviews of their own installations. The perception is that such dependency could be easily exploited by the DAE management to influence the AERB's evaluations and decisions".

To conclude, the experience of over 50 years of experimentation with nuclear power demonstrates that it cannot be considered a safe, economical, or environmentally sustainable source of electricity. It is being recognised the world over that nuclear energy neither ensures true energy security, nor addresses the issue of global warming. Despite powerful lobbies pushing for the expansion of nuclear energy due to concerns about climate change, several Western countries have decided to phase out nuclear power. The United States has not constructed a new nuclear reactor in over two decades. If current trends continue, it appears that the share of nuclear energy globally will only decline in the years to come. India, then, is attempting to swim against the tide by trying to get into nuclear power in a big way, a tragic illustration of the continued relevance of Gandhiji's warning in the epigraph, nearly 60 years after Independence.

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CDM endorsements for nuclear energy?

So far, nuclear energy has not been formally included in CDM credits. If it is, nuclear energy will get the Kyoto stamp of approval

A S PANNEERSELVAN

I HAVE BEEN ASKED to write a comprehensive analysis of the recent Indo-US nuclear agreement. I have to write a requiem for myself. I have spent my entire adult life — as a journalist, as a political commentator and as an activist — fighting the nuclear regime and advocating moves to realise a comprehensive disarmament structure that would really eliminate these weapons of mass destruction from the face of the earth.

There are four said elements in the Indo-US nuclear deal and one unsaid. The four stated positions are: India will separate its civilian programme from its military programme and subject its civilian programme to international safeguards; there will be no need for India to adhere to the nuclear non-proliferation regime; the international Nuclear Supplies Group will start supplying nuclear fuel once the separation takes place; and the deal will ensure energy security for India. The unsaid deal is that the way will be paved for India to get Clean Development Mechanism (CDM) money for its nuclear programme under Article 12 of the Kyoto Protocol.

Before addressing the question of climate change and nuclear energy, it is important to understand the mechanism of the nuclear industrial regime. The uniqueness of the nuclear regime is that it moves swifter than others. All critiques of this regime are primarily reactive. For instance, adjustments in US laws have been made in an unusually expeditious manner. Nearly seven months before President George Bush and Prime Minister Manmohan Singh signed the nuclear deal in Delhi in March 2006, on July 26, 2005, US Congress accepted the Burr Amendment, which considers nuclear energy the cleanest energy, and decided to fund nuclear energy programmes. This is a clear indication that India's nuclear programme would be subsidised by the CDM. All this in the name of a clean environment, being sensitive to climate change, and a reduction in carbon emissions.

The International Atomic Energy Agency (IAEA) is at the forefront in pushing nuclear energy as one of the best options for the CDM. It has taken on the task of explaining the role of nuclear power in achieving sustainable development in developing countries and in mitigating GHG (greenhouse gas) emissions. Three senior members of the Indian nuclear establishment — A K Nema of the Nuclear Power Corporation of India, B K Pathak of the Bhabha Atomic Research Centre and R B Grover, technical advisor to the chairman of the Indian Atomic Energy Commission — have presented the Indian case to the IAEA, which presented it at the Sixth Conference of

Parties to the UNFCCC at The Hague.

These members of the nuclear establishment argue that nuclear power is economically competitive; that coal-based power plants are located far from the pitheads, thereby increasing their total cost; that replacing coal plants with nuclear plants reduces GHG emissions by 1.87 million tonnes of carbon each year; that the total emissions offset over the lifetime of a nuclear power plant is 56 million tonnes of carbon; and that to preserve the environment it is necessary to support the nuclear power option as it has an "unlimited resource base" under the CDM facilities.

So far, nuclear energy has not been formally included in the CDM credits. Developing countries are the key to the nuclear industry's future, yet, to date, orders for new reactors have been scarce. The main barrier is economic. The huge capital cost of a new reactor and long repayment period are significant deterrents. But if CDM credits were factored in, this could change. For example, a 700 MW coal-fired power station emits about 4.5 million tonnes of carbon dioxide (CO_2) a year. If a nuclear reactor was built instead, it could be claimed that it offsets this amount of CO_2. Estimates of the value of CO_2 per tonne vary, but for a CDM project an amount of approximately $ 10-30 a tonne is likely. Thus, the carbon offset by this nuclear reactor over a 10-year period would be valued at between $ 450 million and $ 1.35 billion (less, when future credits are discounted). An agreement between the Western supplier of the reactor and the developing country in which it is being built to subtract the value of the carbon credits from the initial capital cost of the reactor would greatly improve the economics. A 700 MW nuclear reactor costs approximately $ 2.5-3 billion. The CDM credits it generates could cut the capital cost by 10-40%.

Aside from the economic implications, there is also great potential for nuclear plants to undermine domestic action to reduce greenhouse gas emissions. If, for example, Canada were to secure another contract to build two 700 MW reactors in India (most of India's pressurised heavy water reactors are Canadian), it could potentially claim 9 million tonnes of carbon reduction credits per annum — equivalent to approximately 6% of its 1998 carbon dioxide emissions.

If nuclear power is made eligible for the CDM, the Kyoto Protocol will be contributing to the threat of nuclear proliferation. All nuclear power plants produce weapons-usable plutonium. A sphere of plutonium smaller than a tennis ball can be used to make an explosive device that can kill many thousands of people. The two developing countries lobbying most aggressively for CDM credits for nuclear projects are China and India, both of which have active nuclear weapons programmes. Other likely candidates for nuclear credits under the CDM, like South Korea, have only recently halted clandestine programmes to develop a nuclear arsenal.

The threat to global security posed by nuclear proliferation is equal to that of climate change. For the Kyoto Protocol to exacerbate this threat through its mechanisms would be a truly perverse — and dangerous — outcome for the climate convention negotiations. Many developing countries, particularly those in the Pacific and Africa, are concerned that investment in CDM projects will mirror current investment flows and be biased towards high-growth countries like India, China and South Korea. They are rightly seeking an assurance that the CDM will be structured to ensure an equitable distribution of resources among all developing countries.

Allowing nuclear power in the CDM will undermine their efforts. It will see CDM credits sucked in by nuclear mega-projects in countries like China, India and South Korea, further reducing the resources available for sustainable projects in non-nuclear developing countries. CDM credits for nuclear power will be seen as an endorsement of the nuclear industry's argument that it has a role to play in combating climate change. It will be, in effect, the 'Kyoto stamp of approval'. This could encourage developing countries to go down the nuclear road. It could help developed countries that cling to the nuclear dream to justify further subsidies for their domestic nuclear power programmes, extend reactor operating lives, and even undertake new construction. The legitimacy it would give to the nuclear industry could also jeopardise phase-out plans — legislated or *de facto* — in a number of countries. If the CDM is to be an effective instrument for sustainable development, and advance the goal of greenhouse gas reductions, then preventing support to nuclear energy from the Climate Change Convention is essential. Otherwise, a key mechanism of the Kyoto Protocol will become just another nuclear subsidy.

The operative part of the Indo-US deal is: "India would reciprocally agree that it would be ready to assume the same responsibilities and practices and acquire the same benefits and advantages as other leading countries with advanced nuclear technology, such as the United States. These responsibilities and practices consist of identifying and separating civilian and military nuclear facilities and programmes in a phased manner and filing a declaration regarding its civilian facilities with the International Atomic Energy Agency (IAEA); taking a decision to place voluntarily its civilian nuclear facilities under IAEA safeguards; signing and adhering to an Additional Protocol with respect to civilian nuclear facilities; continuing India's unilateral moratorium on nuclear testing; working with the United States for the conclusion of a multilateral Fissile Material Cut Off Treaty; refraining from transfer of enrichment and reprocessing technologies to states that do not have them and supporting international efforts to limit their spread; and ensuring that the necessary steps have been taken to secure nuclear materials and technology through comprehensive export control legislation and through harmonisation and adherence to Missile Technology Control Regime (MTCR) and Nuclear Suppliers Group (NSG) guidelines."

This section of the agreement has generated opposition and criticism in India. The critique from both the left and the right finds fault with compromising India's security and subjecting its sovereign rights to closer international and US scrutiny. It is alleged that India has become a regional rear guard for the US in its strategic positioning against China's growing economic and military might. By offering the new nuclear deal, the United

States has convinced India to give a decent burial to the ambitious Iran-Pakistan-India gas pipeline.

The national sovereignty issue seems to be an old ghost that continues to haunt mainstream Indian political parties. In reality, the Indian defence elite has been working for nearly 25 years to create a twin nuclear architecture whereby the civilian programme will be subjected to international safeguards and secrecy will be maintained for defence nuclear institutions. This doctrine was proposed by Raja Ramanna, former chairman of the Atomic Energy Commission and later minister of defence. In fact, Indian civilian nuclear sites have been under international scrutiny, though not by the IAEA but by the WANU (World Association of Nuclear Users) since the 1980s.

The Department of Atomic Energy (DAE) came out in the open about its weapons programme in May 2000. As a first step, the government and the DAE took away the authority of the Atomic Energy Regulatory Board (AERB) to oversee the safety of a large number of critical nuclear installations meant for the weapons programme at the Bhabha Atomic Research Centre (BARC). Since then, an Internal Safety Committee set up by then BARC director Dr Anil Kakodkar (present chairman of the Atomic Energy Commission) was made responsible for ensuring the safety of the public and the workers from dangers which could emanate from these facilities. This diminishes the responsibility for unbiased independent safety regulations entrusted thus far with the AERB. Neither the Bharatiya Janata Party nor the left raised any objections to that development. There was not a single follow-up story in any newspaper on this issue; not even a single letter to the editor. The present Indo-US nuclear deal is just a formalisation of the action plan conceived by India in the early-1980s and being implemented in stages since 1989.

India was the first country to realise the total ineffectuality of the Nuclear Non-Proliferation Treaty (NPT), deciding to remain outside the NPT. India kept invoking Israel as an example for not signing the NPT. Israel is one of the few countries outside the NPT that has nuclear weapons and the US has never persuaded the Israelis to sign the agreement. The examples of Iran, Iraq, Libya, the apartheid regime of South Africa, and North Korea are often cited as standing proof that signing the NPT is not a guarantee against a weaponisation programme. The Strobe Talbott-Jaswant Singh talks between June 1998 and September 2000 indeed laid the groundwork for the present deal.

It is important to bear in mind the continuity in the overall thrust of the nuclear policy despite the change of guard in both countries. October 13, 1999, was a crucial day: Atal Behari Vajpayee took office with a renewed mandate; and the United States Senate rejected the CTBT. On that day the Global Disarmament Debate died. The new Indo-US defence deal only completes the rites of passage of the dead disarmament debate.

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'India has no choice but to increase emissions'

With the right policy back-up, hydro and nuclear energy could be serious options for India in future, says R K Pachauri

RICHARD MAHAPATRA

'Development versus Environment' was the big challenge of the 1980s. The biggest challenge of the new millennium is 'Energy versus Emissions'. India's economic growth is energy-intensive while its energy profile is dominantly fossil fuel-based. Naturally, India's growing energy consumption is perceived as a major future source of global warming. As global pressure mounts on India to cut its greenhouse gas (GHG) emissions, India is faced with the dilemma: how do you cut back emissions when you have very few options other than fossil fuels?

"Emission is a compulsion for India and we need to emit to grow," says Dr Rajendra K Pachauri, director-general of the Delhi-based The Energy and Resources Institute (TERI) and chairman of the UN's Intergovernmental Panel on Climate Change (IPCC). "Nobody can deprive India of its freedom to grow. But at the same time we should be conscious of global warming as it affects us all."

'Energy versus Emissions' seems to be the biggest challenge for India in the face of global warming. How do you foresee India's energy scenario in this context?

India doesn't have any choice except to increase emissions. India's energy consumption is largely fossil fuel-based. We are importing oil to sustain our consumption. In future it may become difficult to sustain such imports due to rising global oil prices. So we are left with the choice of using coal for power. This is all the more so because we are slow in developing alternative clean fuels. So we will continue using high-emission fuels.

At the same time, given the threat of global warming, we have to make a conscious shift in our energy strategy. Here India can make a diversion from the energy consumption pattern of developed countries by focusing on alternative energy sources. It will be in our favour, and at the same time will help reduce GHG emissions.

As pressure on India to contain its carbon emissions increases, don't you think we should have the freedom to choose an energy policy that is sustainable and socially equitable?

"I believe that nuclear power is clean as far as GHG emissions is concerned. Nuclear power has literally no emissions. Given the constraints of limited options and the wider threat of global warming, nuclear is a serious option for India in future"

Developed countries have attained a level of economic development from which they can afford to reduce emissions. India can't be deprived of development due to that. We have to increase our emissions certainly, to some extent.

I think India has the freedom to choose its energy sources and there is no pressure not to do so. As we have large reserves of coal, we have to depend on that for our energy security. This will lead to global warming. What we need to focus on is how to use the source productively and emit less GHGs. This involves the use of new technologies. By doing so we are not only helping reduce emissions but also maximising the use of our resources.

Pro-nuclear bodies are hitchhiking on the bogey of global warming to push nuclear energy as a 'clean' energy. Do you think it really qualifies as clean energy? Should India adopt it for its energy security?

Yes, I believe that nuclear power is clean as far as GHG emissions is concerned. Nuclear power has literally no emissions. Given the constraints of limited options and the wider threat of global warming, nuclear is a serious option for India in future. Though currently we produce just 3% of our commercial energy from this source, being a viable source it has to go up in future. In this context I think the Indo-US nuclear deal is an important step forward. This will enable India to access better technologies, and also fuel to generate electricity from nuclear technology.

But the risk factors are high in the case of nuclear power generation. What about waste management and the threat of radiation?

I am told that the new breed of nuclear reactors is quite safe in operations. Of course we have to take care of the environmental factors. But to turn it into an important mode of energy, we need proper public policy deliberation. It is for the government to do so.

Nuclear energy is also expensive and may not be suitable for the Indian market.

I don't think it is that much more expensive, or will become so. Various studies have shown that nuclear energy is quite competitive and cheaper than a few other sources. It is a very viable option.

But you said that India would have to continue with fossil fuels. The reality is that 70% of our population is in rural India and their energy source is primarily biomass. If this section of the population is to be brought under the fossil fuel mode, don't you think it will be a huge economic as well as environmental burden?

That is what I told you in the beginning. We can't deprive a large section of the population of modern energy. At the same time, we have limited sources. Fossil fuel has to be an important component. So emissions is the reality. That is the price we have to pay for development.

But the rural sector has huge opportunities for renewable energy. We need to spread the use of modern cooking fuels in rural areas, and for electricity purposes we need to depend on renewables. We simply can't deprive a major section of people of modern facilities. But for this again we need a change in energy policy targeted at the rural section.

If renewables have such potential why doesn't the Clean Development Mechanism (CDM) have many projects related to renewable energy?

The CDM is a market-driven mechanism. Its in-built design is such that people who want to reduce emissions will go for low-cost projects. Renewable energy projects are really expensive, thus they do not feature prominently under the CDM. Also, there are problems of scale. CDM projects are small and limited in scope, thus raising the administrative cost. A large-scale project will become cheaper.

One way out is to adopt a cluster approach. Under this, one entity is given charge of an area under which it can take up projects to reduce GHG emissions. This will substantially bring down the cost thus making it lucrative for the client.

Hydropower is considered safe and has been included under the CDM. Don't you think big hydropower dams are a threat to the local ecology? Isn't it like solving a problem by creating another problem?

There is nothing like 'big dams are bad'. I'll put it this way: there are good dams and bad dams. With the right policy back-up, big dams can reduce the damage and also benefit people a lot. So the idea is to correct the problems of big dams.

There is the question of rehabilitation and resettlement. Don't you think our track record on this has been poor?

Yes, as far as rehabilitation and resettlement is concerned it is not so good. But over a period of time, due to civil society concerns and campaigns, the government has learnt lessons on how to correct the (lapses). Hydropower is a clean option and can be generated safely, taking care of everybody's concerns.

Commoditising power

Power generation is the primary contributor to greenhouse gas emissions in India. But government policy, as stated in the Electricity Act 2003, fails to address the environmental concerns arising from the unbridled burning of fossil fuels. Instead, it puts the premium on financial sustainability of power utilities, completely neglecting environmental sustainability

SUDHA MAHALINGAM

ELECTRICITY IS A CONCURRENT SUBJECT under the provisions of the Indian Constitution. Yet, for nearly six decades, two central laws, viz the Electric Supply Act 1948 and the Indian Electricity Act 1910, defined the rules of business in the generation, transmission and supply of electricity in the country. In 2003, the Indian Parliament repealed the two laws and replaced them with a comprehensive new legislation that would usher in a new era in the structure and functioning of the electric supply industry. The Electricity Act 2003 came into effect in June 2005. It is seen as the culmination of a decade-long experiment with a new governance paradigm in India's power sector.

The new law does herald a paradigm shift in the manner in which electricity will be generated and supplied in this country. The centrepiece of the new legislation is 'open access', a mechanism through which limited markets are sought to be introduced in the business of electric supply. The proposed markets will be limited to those who consume more than 1 megawatt of electricity per year. These consumers can now source their electric supply directly from any generator or utility, while all those who consume less than this threshold limit will continue to depend solely on their respective local utilities. In effect, this would mean that only large industrial and commercial consumers can reap the benefits of contestability in electric supply, creating a wedge among consumers. Apart from this, the new law also liberalises electricity generation, doing away with the need to obtain a licence for setting up power-generating stations, except in the case of large hydroelectric projects. And finally, it sets up independent regulators, distancing the government from the politically sensitive task of tariff-setting.

As India moves away from the era of vertically-integrated state-owned monopoly utilities to unbundled, corporatised and occasionally privatised utilities regulated by independent regulators, how does the new legal regime factor in key concerns relating to social and environmental aspects of power supply? Does the new law ensure equity in access to electric supply in a country where more than half the households still remain unconnected? Does the new law extend the hope that India's poor and rural households will literally and finally see light at the end of the tunnel, regardless of their ability to pay? How does the Electricity Act 2003 address the growing environmental concerns arising from unbridled burning of fossil fuels? After all, the national communication submitted by India's Ministry of Environment and Forests to the Kyoto Secretariat unambiguously acknowledges power generation as the primary contributor to greenhouse gas emissions. Does the new law internalise this and other environmental imperatives in its framework?

Unfortunately, the new law fritters away a golden opportunity to put the power sector on the path of sustainable and equitable development. At best, the Electricity Act 2003 makes a nodding concession to the environmental and social aspects of the power sector, almost as an afterthought. The thrust is on restoring the financial viability of India's beleaguered state electricity boards and, as such, its provisions are designed to address this concern, not the concerns of equity or environment, except in passing. The new law emphasises cost-recovery through cost-reflective tariffs and phased reduction and eventual elimination of cross-subsidies, with its attendant adverse consequences for affordability, especially to poor and marginalised sections of society.

Environment

The Electricity Act 2003 is a detailed piece of legislation divided into 18 parts and 185 sections. It is a measure of the importance India's policymakers assign to the environmental dimension of electric supply that only two provisions actually address the environment, and that too tangentially.

In the context of the obligations of the licensee in the transmission and supply of electricity, Section 67 (1) states that the 'appropriate authority' may stipulate the avoidance of public nuisance, environmental damage and unnecessary damage to public and private property by such works. Thus, environment is lumped along with public nuisance, etc, more as an afterthought. In this context, it is noteworthy that environmental damage occurring in the transmission and supply of electricity is unlikely to be significant, whereas environmental damage caused by power generation from fossil fuels can be considerable. Yet, the law completely ignores this aspect.

Nearly three-quarters of India's electricity comes from burning fossil fuels, of which coal alone accounts for 73%. In fact, the power sector consumes 78% of coal produced in the country. Indian coal has up to 50% flyash for which, thus far, no safe disposal has been worked out. Besides, burning coal releases enormous quantities of greenhouse gases. Increasing the share of natural gas in the thermal power basket will have a salutary effect on the environment. Increasing the share of renewables

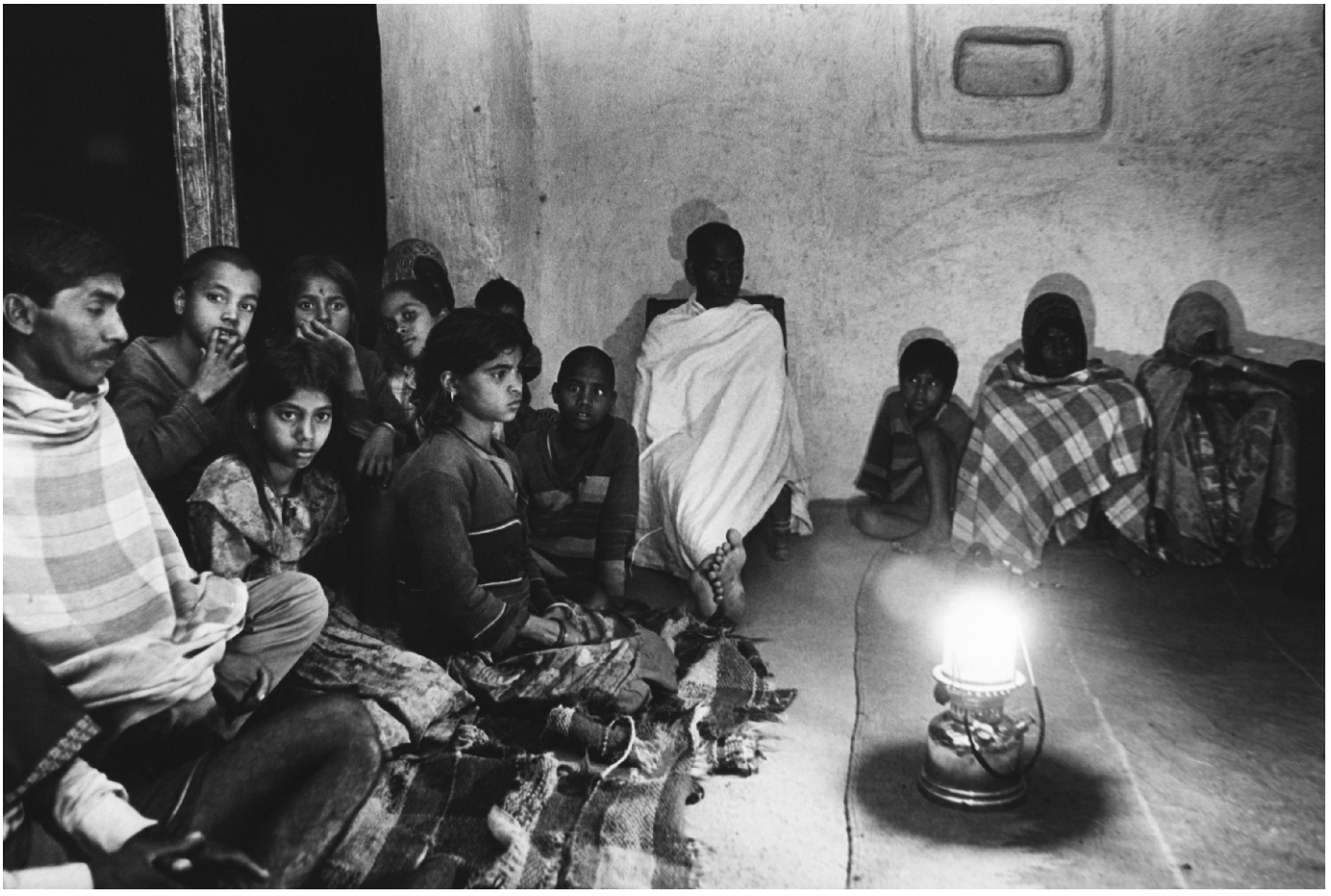
could be another option, but the law is silent on the relative environmental desirability of different fuels used for thermal power generation. It does not stipulate development of the sector in an environmentally sustainable manner.

Section 61 in Part VII of the Electricity Act 2003 contains the only concession made by the law to the environment. This provision requires the electricity regulatory commissions to promote "co-generation and generation of electricity from renewable sources of energy". At present, renewable sources including wind energy, solar and biomass constitute less than 3% of total electricity generation in the country. Increasing their share to even 10% of the total will require meticulous planning and enormous investments in renewable energy. A mere mandate to the regulators to 'promote' renewable energy without providing the necessary wherewithal can hardly achieve the desired results. Besides, even if the regulators would like to comply with this mandate, there are not enough sources of renewable energy in many states. While regulators can perhaps provide incentives for renewable energy through appropriate tariffs, and hope that entrepreneurs will come forward to set them up, they are themselves powerless to ensure that this happens.

Section 4 requires the central government to prepare, in consultation with state governments, a national policy to permit stand-alone systems including those based on renewable sources of energy and non-conventional sources of energy for rural areas. This does find expression in the National Electricity Policy, albeit with a caveat. The policy recommends the establishment of distributed generation to be "done either through conventional or non-conventional methods of electricity generation, whichever is more suitable and economical. Non-conventional sources of energy could be utilised even where grid connectivity exists, provided it is found to be cost-effective". Thus, financial cost, rather than cost to the environment, seems to be the deciding factor when it comes to renewables.

In the context of environment, hydroelectricity could be a double-edged solution. While hydel power does not release greenhouse gases, big dams entail huge efforts in relief, relocation and rehabilitation. Besides, seismicity and vulnerability to flooding make them less than optimal solutions from the environmental point of view. Currently, hydroelectricity constitutes nearly a quarter of the electricity produced in India. The sole provision in the new law that addresses hydroelectric projects focuses almost exclusively on factors other than the environment. Section 8 (a) of the Electricity Act 2003 requires the concerned authority to ensure that the proposed river-works will not prejudice prospects for the best ultimate development of the river or its tributaries for power generation, consistent

Raaj Dayal



with the requirements of drinking water, irrigation, navigation, flood control or other public purposes, and "for this purpose, the authority shall satisfy itself, after consultation with the state government, the central government, or such other agencies as it may deem appropriate, that an adequate study has been made of the optimum location of dams and other river-works".

Thus it is evident that the environment was far from the minds of our legislators when they drew up the provisions of the Electricity Act 2003. Nevertheless, it must be pointed out that like all other sectors, the electricity sector is also subject to environmental laws, rules and regulations of the Government of India. The Ministry of Environment and Forests (MoEF), Government of India, is the nodal administrative agency for environmental regulation. The Environmental Impact Assessment (EIA) Notification of the MoEF requires all projects — including power-generation projects — to obtain environmental clearance. EIA requires the project promoter to prepare an assessment of the potential impact of his/her project on the environment and the mitigation measures proposed to be taken to minimise such impact. The law has provisions for conducting public hearings, although this is observed more in the breach as some studies show. Similarly, the power sector is also subject to the provisions of the Environmental Protection Act.

Equitable access

As mentioned earlier, the thrust of the new law is on restoring the financial viability of electric utilities rather than equity or affordability of electric supply. However, there are a few provisions that do address rural electrification. In a significant but insufficient measure, the law allows any person to generate and distribute electricity in a rural area without having to obtain a licence. This provision is expected to facilitate extension of electric supply to hitherto unconnected areas, provided there is adequate demand accompanied by capacity to pay. Note the operative phrase, 'capacity to pay'.

In another half-hearted measure ostensibly aimed at protecting the interests of marginal consumers currently cross-subsidised by industrial and commercial consumers, Section 40 © (ii) of the Electricity Act 2003 requires any consumer availing of 'open access' to pay a cross-subsidy surcharge determined by the regulator. This cross-subsidy surcharge is expected to compensate the utility for charging certain sections of consumers — mostly agriculturists — tariffs that do not cover full cost to supply. However, in the same breath, the law also requires the regulator to set a time frame for progressive elimination of cross-subsidies. Section 61 further states that the tariffs should progressively reflect cost of supply of electricity.

The irony is that if every consumer has to pay the full cost of what it costs to supply his/her premises, industrial consumers drawing high tension power will pay the lowest tariffs, while rural consumers who draw power at low voltage and for whom long lines have to be drawn to carry power, will pay the steepest tariffs. Thus, there is an inherent inequity in the law which requires consumers with the lowest capacity to pay the steepest tariffs even as industrial consumers can get away with substantially lower tariffs, if cross-subsidies are eliminated altogether, as envisaged by the law.

The law does provide that state governments could directly subsidise the marginal consumer category, and many state governments have been allocating substantial sums towards direct subsidy. But how long can resource-constrained state governments sustain direct subsidies is a moot point. If, for some reason, the state government is unable to fork out the subsidy, the utility is free to charge cost-reflective tariffs. Thus the new law is an attempt at commoditisation of electricity even as the National Electricity Policy formulated under Section 6 of the Electricity Act 2003 admits that electricity is a basic human need.

As for universal access, Section 6 states: "The appropriate government shall endeavour to supply electricity to all areas including villages and hamlets." There are other provisions which require the utility to supply power on demand, but this is circumscribed by the proviso that such supply is contingent on the ability of the consumer to pay for laying the necessary cables to his premises. Thus ability to pay is a *sine qua non* for securing access.

The Electricity Act 2003 does not make any reference to equity in access to electricity. The National Electricity Policy stresses the need to electrify rural households that still remain unconnected. However, it goes on to say: "Consumers, particularly those who are ready to pay a tariff which reflects efficient costs, have the right to get uninterrupted 24-hour supply of quality power. About 56% of rural households have not yet been electrified even though many of these households are willing to pay for electricity." Thus, the emphasis is on consumers willing to pay, not those who cannot afford to pay cost-reflective tariffs. Nevertheless, the policy does want electricity to reach all households in the next five years, and that too at reasonable rates. If only policy statements and pious intent were horses, all poor households would ride them!

If the Electricity Act 2003 conveys one message loud and clear, it is that electricity is a commodity and those who can afford it can avail of it. As for the environment, the new law puts a premium on financial sustainability of utilities, to the utter neglect of environmental sustainability — as though the two were mutually exclusive.

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The power plant in your backyard

In the not-too-distant future, power plants will shift from large, remote centralised stations to rooftops, basements, backyards, or nearby hill ranges. Experts predict that half the world's energy supply by 2050 will be from renewables. But there are several obstacles to the integration and effective market penetration of renewables

G M PILLAI

THE FUTURE of the power system is in decentralised generation (DG). In the not-too-distant future, power plants will shift from large, remote centralised stations to rooftops, basements, backyards, driveways or your nearby hill ranges…Internationally acclaimed energy expert Amory Lovins makes the following prediction: "The central power plant, like much bulk electric transmission, will soon become a white elephant, uneconomic to run, and difficult to sell. Such plants are unlikely to survive in significant numbers by 2030 in any market economy."

Distributed generation has the following features: 1) located near the consumers or on-site, 2) connected at the distribution end of the grid or no grid and 3) the size of individual units would be small, ranging from a few kilowatts to a few megawatts. It provides easy access to power for tailend users like rural people, avoids high transmission and distribution costs, provides reliable and quality power, is energy-efficient and climate-friendly. Distributed or decentralised power generation is the perfect complement to decentralised development, decentralised governance and local economy. It is predicted that by 2010, 25-30% of new generation will be distributed. The petroleum major Royal Dutch/Shell group which has made a big foray into renewables, has come up with a report predicting that half the world's energy supply by 2050 will be from renewables. Amory Lovins feels that this is not only highly likely, but could be surpassed.

Energy security is of paramount importance for our national security. Energy security is conventionally understood in terms of the risks of fuel supply disruption and fuel price volatility... Some experts predict that by 2010 the price of crude would go up to $ 100 per barrel. Unlike the oil crises of the 1970s and 1980s which were politically created, the current price increases are fuelled by supply not matching demand. Despite new finds the fact remains that 70% of the world's daily supply comes from oil fields that have been drilled for 30 years or more. For the fast-growing Indian economy, this news is especially bad. In 2003-04, India had an import bill of Rs 83,528 crore, more than double the 1999-2000 figure.

A very significant study regarding oil supplies has been done by Colin J Campbell and Jean H Laherrere. Their findings clearly indicate that by 2010 the supply of oil will be unable to keep up with demand. The 'Hubbert's Peak' would be reached and the permanent decline in oil production will begin by 2010. By that time the 'BRIC countries' (Brazil, Russia, India and China) will need large chunks of oil, especially because of the fast growth of the Indian and Chinese economies. It is predicted that if India and China continue to grow at current rates, the demand for oil will rise by 6% per year. To meet this demand, world output will have to rise by 43% by 2010. Prices might then shoot up to the $ 100 per barrel level. The impact on our import bill and balance of payment will be very serious.

The National Security Council of the Government of India has recently circulated a paper to Union ministers outlining measures for our future energy security. Development of renewables and energy conservation are the two main focal areas in this paper. More significant is the fact that, probably for the first time, an official document admits that conventional fuels in India are threatened with extinction: oil, gas, uranium and coal would be exhausted in 25, 40, 80 and 200 years respectively. The probable extinction dates for oil and gas seem fairly accurate.

Renewables offer a direct means of dealing with these concerns. First of all, they are foreign exchange neutral. They are dependent on our own natural resources. They will never become extinct. The issues relating to their integration, high initial costs and investments required can easily be tackled through innovative legislative, policy and financial mechanisms. A recent report of the G8 Renewable Energy Task Force estimates that accelerating deployment of renewables might require 'learning investments' in the order of $ 100 billion. This is not a big figure, if you compare it to the economic losses that the increase in oil prices can create. The loss so created by a 10% price increase of oil in IEA countries would amount to billions of US dollars. This is more than enough to finance the 'learning investments' for deploying renewables.

Integration issues

Conventional power systems are not designed for parallel operation of a DG system. Today, in India, the penetration of decentralised generation systems in the grid is hardly 3%. As the contribution of decentralised generation to the grid increases, the operation and control of the grid will generate new technical challenges. Hence, conventional power utilities should try to study this issue in a scientific way and evolve solutions, rather than blindly opposing these new technologies. The integration of these power technologies in the existing power system is a challenge we should address. In order to allow optimised integration of the new technologies into the mainstream, radical changes and renewal in existing energy

infrastructure will have to be made.

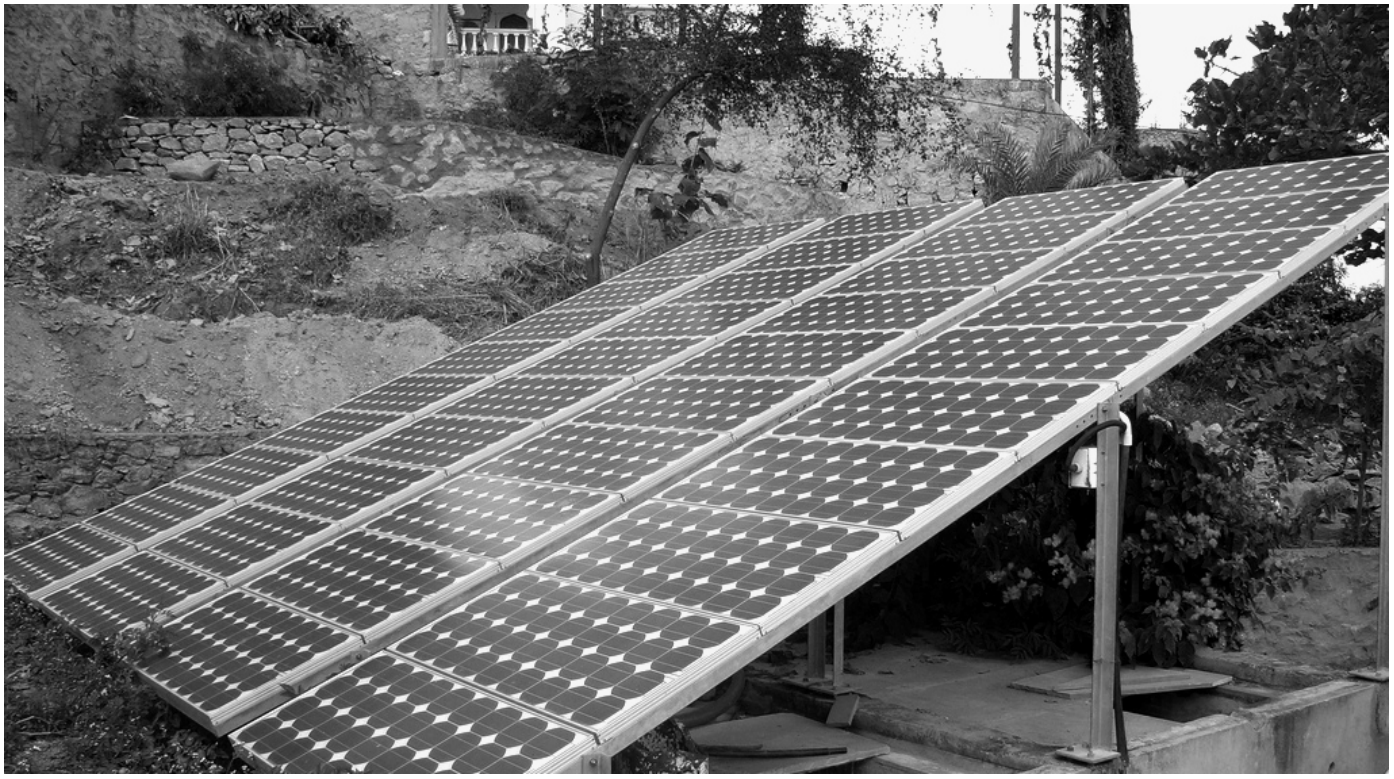
The issue of integration is at once technical and non-technical. Technical issues are not insurmountable. In a diverse country like India, the strategy to integrate renewables into the energy system will vary from state to state and within states, from one region to the other. Most of the renewable resources are geo-specific. So, location-specific strategies will have to be worked out. If integration is to be a reality, we will have to also address the following issues: 1) The intermittent character of some sources of renewable power. 2) The need for energy storage, in case of surplus generation. 3) Energy and load management.

Production of electricity from wind, solar photovoltaic and wave energy will be intermittent in nature, depending on the availability of the resource. Biomass-based power plants based on various sources like agricultural residues, bagasse from sugar factories, urban wastes, etc, can operate continuously. Admittedly, intermittent sources cannot cover peak loads. But in a situation of energy shortages, as is the case in India, any power produced any time is consumed. In a power system with diversified sources, balancing one against the other is also possible through proper load dispatch management. For example, hydropower stations can be backed down during peak wind power production. The stored water can be used later for peak load management. Storage of renewable power is another major issue being studied worldwide, to surmount the intermittency factor. Right now, with less than 3% penetration of intermittent renewables into the grid, storage is not an area of critical concern. In power-deficit countries like India, power is consumed as soon as it is produced and peak load management can be achieved through other sources…(The point is) that the problems created by the intermittent nature of some renewables are surmountable.

Conventional mindsets are the biggest barriers to integration. These new technologies are also faced with market acceptability and credibility problems. The economic, policy and technological environment is still not very conducive for the spread of these innovations. There are serious technical, economic and market distortions. Strict quality control and laying down of standards would help increase credibility. The malfunctions of some systems like solar street lights have caused widespread distrust about the new technologies. The non-availability of specialised engineers, technicians and after-sales service mechanisms have seriously hampered the growth of many renewable energy technologies. Development of appropriate, academic, technical and training infrastructure will have a beneficial influence in increasing the credibility and market acceptance of these technologies.

Cost-competitiveness of renewables

The competitiveness of renewable technologies vis-a-vis conventional systems is another important factor determining their market penetration. There are two costs involved — the capital cost and the cost of producing power. The two are interrelated. As renewable technologies achieve economies of scale, the capital cost should come down. To some extent, this has been happening in the case of wind turbines. For some others like solar photovoltaics, the high capital cost is the biggest market barrier. Nevertheless, it should be noted that the price of solar photovoltaics has also dropped between one-third



and one-fifth of the cost in 1980. This cost is expected to further fall sharply in the next five years.

It is not widely known that conventional power production is the biggest polluter. Most people think automobiles and factory chimneys are the only culprits. The environmental and health costs of pollution are hidden. Now environmental economists have begun to unearth these hidden costs and quantify damages on a case-to-case basis. The World Bank estimates that the environmental and health costs of air pollution in China, primarily due to burning of coal, may be as high as 13% of China's gross domestic product by 2020.

In fact, a recent study done by the British government showed that by 2020, wind power will be the cheapest option for electricity generation, of all the technologies. Even today, it is a cheap source if life-cycle costing is considered and the environmental advantages are factored in.

There are numerous barriers preventing effective market penetration of renewables. The unfair pricing of power is only one of them. Any commodity is priced based on the cost of producing it, its utility for society, brand value, and of course, a certain profit for the producer. Conventional power is priced without taking into consideration all these factors. Most large hydropower projects in India function at less than half the rated capacity. While computing the cost of production of power from these projects, only the operational cost is considered, whereas ideally, the cost of capital investment should also be considered. The externalities of conventional power production, viz environmental cost, health costs, cost of displacement, adverse social impact, etc, are not factored in. They also enjoy many hidden subsidies beginning with mining and transportation of coal, free supporting infrastructure provided by government, etc. Distorted prices worked out by ignoring such factors give wrong signals to the market. Renewable power is non-polluting, decentralised, causes no displacement and facilitates large-scale employment. Hence, grid-connected green power is eligible for a level playing field in tariff determination. The new Indian Electricity Act 2003 recognises this to some extent and has empowered the State Regulatory Commissions to fix suitable tariffs for renewable power.

The challenges faced by governments in formulating future energy policies over the coming years are too many. They have to ensure energy security for a growing population, ensure economic growth to contain poverty, see that such growth is sustainable, address environmental and climatic change, create more employment, and facilitate development of new technologies. Renewable energy is the only energy source which can address these issues and impact all of them in a positive way. It is abundant and not source-limited, it is sustainable, it is environment-friendly, it creates new employment opportunities, production is decentralised and would emerge as a cheaper option in the near future.

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Waste-to-energy or waste-to-pollution?

Incineration technologies have been completely discredited. But the government continues to experiment with them

GOPAL KRISHNA

ACKNOWLEDGING a news report on the closure of a Rs 84 crore municipal-solid-waste (MSW)-to-electricity plant in Lucknow, on May 6, 2005, the Supreme Court ordered a stay on any further subsidies for proposed and future municipal-waste-to-electricity (WTE) projects. It sought an inspection of the functioning and records of the Lucknow plant by a central government-constituted committee.

When the Centre commissioned the plant, the objective was to generate 5 MW of electricity using biodegradable waste. The plant generated a mere 0.3 to 0.5 MW.

In line with the court order, the central government constituted a committee of experts to inspect the functioning of waste-to-energy plants with a special focus on the Lucknow-based centrally-sponsored waste-to-electricity plant. The main purpose of the independent non-government committee's review is to investigate the propriety and need for ongoing subsidies for technically and economically unviable municipal-waste-to-electricity projects in the country.

However, far from investigating the issue, the committee was taken over by the Union Ministry of Non-Conventional Energy Sources (MNES) which, in July 2005, despite the May 2005 court order, widely publicised its grants and subsidies for waste-to-electricity (WTE), including 'burn technologies' which violate India's international commitments. Thus the MNES — the very ministry that is to be investigated — constituted the committee, a clear conflict of interest.

Ignoring the facts regarding the composition of Indian waste, which has a low calorific value and is hence unsuitable for electricity-generation, ministries in the central government continue to experiment with this technology at considerable public cost. Despite the failure of the same technology in Timarpur, Delhi, on March 14, 2005, the Municipal Corporation of Delhi (MCD) signed another agreement for an incinerator plant to generate electricity from waste with Infrastructure Leasing and Financial Services Limited (IL&FSL).

The MNES is also implementing a national programme on energy recovery from urban and industrial waste, to promote new technologies such as bio-methanation, pyrolysis/gasification and combustion for the processing and disposal of waste.

Researchers of waste suggest that composting and recycling are better alternatives as they save the huge amounts of energy required for incineration. Waste incineration encourages a one-

way flow of material on a finite planet, thus making the task of conserving resources and reducing waste more difficult, not easier. On one occasion, President A P J Abdul Kalam rightly summed up the need for integrated zero waste management. He illustrated it by referring to a village of around 2,400 families that generates over 48 tonnes of garbage a year. The garbage is converted into manure and recyclable waste, generating over Rs 3 lakh in revenue. This scheme provides employment to many people in the village. Measures like these promote sustainable development, rather than introducing failed polluting technologies that turn citizens into guinea pigs for experiments.

However, the President appeared a little misguided when he said in his Republic Day Speech in January 2006: "The Bangalore Municipal Corporation is in the process of implementing an 8 MW power plant using solid municipal waste through the BOOT (Build, Own, Operate and Transfer) scheme. The power plant is similar to what we have in Hyderabad and Vijayawada." These plants are based on completely discredited incineration technologies.

Waste incineration systems (including waste pelletisation, pyrolysis and gasification systems) produce pollutants that are detrimental to both human health and the environment. They are expensive and do not eliminate or even adequately control toxic emissions from today's chemically complex waste. Even new incinerators release toxic metals, dioxins and acid gases. Far from eliminating the problem of landfills, waste incinerator systems produce toxic ash and other residues. They release incinerator ash into the environment, which subsequently enters the foodchain.

The MNES's waste-to-energy programme to maximise energy recovery is technologically incompatible with reducing dioxin emissions. Dioxins are lethal Persistent Organic Pollutants (POPs) that cause irreparable environmental and health damage.

Incinerator technology intervention in the waste stream distorts waste management. Such systems rely on minimum guaranteed waste flows. They indirectly promote waste generation, whilst hindering waste prevention, reuse, composting, recycling and recycling-based community economic development. Such systems cost cities and municipalities more, and provide fewer jobs than do comprehensive recycling and composting schemes. They prohibit the development of local recycling-based industry.

Waste-to-energy projects are being promoted in manifest violation of international environmental norms. Incineration of waste violates the Kyoto Protocol, which regards waste incineration as a greenhouse gas emitter. It also violates the Stockholm Convention on POPs which calls for improvements in waste management with the aim of stopping the open and uncontrolled burning of waste. It violates the recommendations of the United Nations Environment Programme's (UNEP's) Global Assessment on Mercury which includes measures aimed at reducing or eliminating mercury emissions from waste incineration, because, unlike other heavy metals, mercury has special properties that make it difficult to capture in many control devices. It violates the Dhaka Declaration on Waste Management adopted by the South Asian Association for Regional Cooperation (SAARC) in October 2004. According to this declaration, SAARC countries cannot opt for incineration and other unproven technologies.

It also goes against national legislation and norms such as the Municipal Solid Waste (Management and Handling) Rules, 2000, according to which it is illegal to incinerate chlorinated plastics (like PVC) and waste that's been chemically treated with a chlorinated disinfectant. And it ignores the recommendations of the Supreme Court-constituted committee on waste management.

According to the 'White Paper on Pollution in Delhi with an Action Plan', prepared by the MoEF: "The experiences of the incineration plant at Timarpur, Delhi, and the briquette plant at Bombay support the fact that thermal treatment of municipal solid waste is not feasible in situations where the waste has a low calorific value. A critical analysis of biological treatment as an option was undertaken for processing of municipal solid waste in Delhi and it has been recommended that composting will be a viable option. Considering the large quantities of waste requiring to be processed, a mechanical composting plant will be needed."

It is therefore incumbent upon India's policymakers to exclude waste, waste resources, waste pelletisation, waste incineration, pyrolysis and gasification technologies from qualifying as renewable energy/fuel sources and to stop offering renewable energy subsidies/loans for burn-technology-based waste-to-energy programmes and policies. The high-cost routes must be avoided. Instead, appropriate methods such as small-scale bio-methanation, composting and proper recycling should be propagated.

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Renewable energy potential and achievements in India

	Potential	Cumulative achievement
Biogas plant	120 lakh	36.71 lakh
Improved chulhas	1,200 lakh	339 lakh
Wind	45,000 MW	2,980
Small hydro	15,000 MW	1,693 MW
Biomass power/cogeneration	19.500 MW	727 MW
Biomass gasifiers		62 MW
Solar PV	20 MW/sq km	191 MW*
Waste-to-energy	1,700 MW	46.50 MW
Solar water heating	1,400 lakh sq m Collector area	10.00 lakh sq m Collector area
* Of this 105 MWPSPV products have been exported		

Source: MNES Annual Report, 2004-05

Biofuels: A reality check

President Kalam envisions millions of hectares of wasteland greened with oil-bearing jatropha. All the sugarcane-growing states are excited about bio-ethanol. Mercedes-Benzes have been run on bio-diesel blends. But is the hype around biofuels to be believed?

RANJIT DEVRAJ

IF THE CURRENT HYPE around biofuels is to be believed, in a few short years, India would not only have significantly reduced its petroleum import bills but also provided worthwhile employment to millions of farmers in rural areas. Vast acreages of wasteland would be green with oil-bearing jatropha and other vegetation heavy with enough clean carbon to power sizeable chunks of transport and industry and even earn the country tonnes of Clean Development Mechanism (CDM) credits.

Reality check: To begin with there is an entrenched petroleum import lobby in the country that no one dares tackle. Those in the know speak in undertones about a self-perpetuating system complete with shadowy middlemen and fat offshore commissions that make the very idea of biofuels or any form of alternative energy laughable. Crude oil, as an old Arab said, is the very blood of Satan.

According to President Abdul Kalam's PURA (Providing Urban Facilities in Rural Areas) plan, bio-diesel plants, especially jatropha, if grown on 11 million hectares of wasteland, can yield approximately Rs 200 billion a year and provide employment to over 12 million people — both in plantations and in the extraction and processing units. In all, India has 63 million hectares of wasteland. "Can there be a better project than this for coherent development of our rural sector and sustainable business proposition for industry?" the President has demanded.

Not many would contradict the President. But Alok Adholyeya, Director of Biotechnology and Management of Bioresources at The Energy and Resources Institute (TERI) contends that if it was at all possible to green India's wastelands, there would be no wastelands left. Not only that, it would always be possible to find crops, including food crops, that could yield faster and bigger profits. Adholyeya says the idea that jatropha can be grown anywhere and without any input belongs in the realm of wishful thinking. In any case, irrigation and fertilisers are needed for commercial-level yields. TERI has taken care to see that its own plantations are in areas with sufficient rainfall. TERI's studies have also shown that technological inputs such as inoculation of jatropha plants with mycorrhiza are needed to improve jatropha nutrition. Needless to say, this calls for the kind of attention and investment that existing agriculture does not receive.

Of the many arguments trotted out in favour of biofuels, the most compelling is that it could help Indian industries avail of CDM benefits as defined under the Kyoto Protocol. But a closer look reveals that there is yet to be anything like an approved methodology. There may never be one. The trouble here is that biofuel projects fall under the 'fuel-switch' category. Essentially, this means that not only do emissions from the plantations and the processing units need to be taken into account in assessments but also the end-use of the final product. It does not take genius to understand that in Indian conditions it would be impossible to monitor whether the end-users are taking their diesel (or petrol) blended or neat. Besides, individual projects, in a country where farmers work handkerchief-sized plots, may never be large enough to attract the buyers of certified emission reductions (CERs) — unless farmers get smart and form large cooperatives. Someone should ask Verghese Kurien.

The case for bio-ethanol has greatly excited politicians from sugarcane-growing states for decades. The example of Brazil saving tens of billions of dollars over the past three decades has been held out. As also the fact that bio-ethanol can be blended into petrol to the extent of 20% without engine modification. But it did not take very long to realise that conditions in India are different and that availability of bio-ethanol is bound to fluctuate according to sugarcane production. The simple fact is that sugar is a politically and culturally-sensitive commodity in this country. Maybe this is why no government has dared to issue a clear policy directive on bio-ethanol. As a result, there have been many false starts by impatient industrialists, and some have come to grief.

The fixation on jatropha for bio-diesel and sugarcane for bio-ethanol goes back to the recommendation of the Committee on the Development of Bio-fuels (CDB) submitted in April 2003.

So what is the way forward? Alok Adholyeya still sees hope in the corporate sector which is keen on experimenting with new technologies. But the real driving force could be the sheer demand for cheap fuels that is expected to be generated by the common man. According to World Energy Outlook (2005) in a business-as-usual scenario, by 2030 India will be consuming 5.6 million barrels of oil per day, of which 94% will be met through imports. There is also growing public concern at the deterioration of the environment from harmful emissions. Court orders compelling public transporters in Mumbai and Delhi to switch to CNG reflect this concern and have definitely spurred the search for newer biofuels and technologies. Entrepreneurs are now seriously looking at producing bio-ethanol from crop residues such as rice straw and bagasse.

There are also plants like sweet sorghum which have a far higher yield than sugarcane or grain. The technology for producing ethanol from biomass, which is abundant in this country, is promising but could take a few more years to develop.

Similarly, for bio-diesel production, Adholyeya advocates examination of "multiple feedstock", which means looking at several promising crops rather than being fixated on jatropha which is not native to this country. There are local candidates such as mahua, neem, rice bran oil, palm oil and a dozen other species with proven suitability to this country's agro-climatic conditions.

What is most important is that as bio-diesel availability — from whatever source — improves, so must the capacity for oil extraction and processing. And this calls for suitable policy initiatives that encourage investment by private entrepreneurship. This could start with exemptions on sales tax, excise and duty, plus support for transport. As things stand the price of bio-diesel is not very different from the average of Rs 25 per litre for regular diesel. A sales tax exemption of 9% and excise duty of 7% can be considered a promotional step.

Seeing is believing. TERI plans to demonstrate the economics of biofuels with its 8,000 hectares under jatropha in Andhra Pradesh which will attain 'seed-to-oil' capacity in the next four years. The University of Hohenheim has been developing diesel blends in collaboration with the Council for Scientific and Industrial Research (CSIR) which have been tested on Mercedes-Benz C-class cars without a murmur. But the best demonstration of bio-diesel power comes from Bastar district where the tribals have, for some time now, been using jatropha oil to power their pumps and farm equipment. But then they do not have to wait for policy pronouncements from reluctant governments.

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Can jatropha fuel a Mercedes?

'Biofuel' is a broad term covering all fuels produced from earth-based or agro-based products. Generally, liquid transport fuels produced from plant material or recycled vegetable oils are called biofuels. Ethanol is a biofuel which has been used in automobiles or agro-based products for some time in countries like Brazil. Biofuels have the potential to displace substantial amounts of petroleum use in transport over the next few decades. They can be blended with petro-products, or in some cases, used exclusively to run internal combustion engines.

Powered by diesel fuel made of jatropha seeds this Mercedes-Benz C 220 CDI covered a distance of 5,900 km across India.

In 2002, the Government of India issued a notification declaring it mandatory to use a 5% ethanol blend in petrol in nine states and four union territories, beginning January 1, 2003. However, this has not been implemented. In 2003, a draft national biofuel policy was also discussed at various fora. It has been reported that a national biodiesel policy will be announced by August 2005. A National Biofuel Fund of Rs 1,400 crore to promote bio-diesel production is also talked about.

Bio-diesel is a recent term used to denote biofuel produced by processing non-edible oilseeds. In India, such non-edible oil can be produced from seeds of plants like *Jatwpha curcas, Pongamia pinnata, Hevea braziliensis* (rubber), *Madhuca indica* (mahua), cotton, neem, etc. *Jatwpha curcas* is the species being promoted in India for production of bio-diesel. It is an indigenous wild bush or tree that grows well in semi-arid marginal or wastelands and is found in many tropical countries. Oil is extracted from the dry seeds of this plant. Through the process of transesterification, the oils are converted to a product called Jatropha Methyl Ester (JME) or bio-diesel. Studies and trials done by IISc, Bangalore, have shown that this bio-diesel can be used to fully power an automobile, run agricultural pumps, etc, without blending or modification of the original diesel engines. Recently, Daimler Chrysler India Ltd, in collaboration with Central Salt and Marine Chemicals Research Institute, has done a 6,000 km road test of a Mercedes C-class car exclusively using bio-diesel. Similar tests were done by Tata Motors in collaboration with Indian Oil Corporation. However, the government initially plans to go the petro-diesel blending route, upto a certain percentage.

Meanwhile, criticism is also surfacing against large-scale planting of a poisonous weed like jatropha. Some people fear its adverse impact on biodiversity. Irrigating such large tracts of wasteland for the first three years after planting, using scarce water resources, is another big question. Others contest the claim that it will be cheaper than diesel. Since combustion of bio-diesel will result in CO_2 emissions, its environment-friendliness is also suspect. What is needed is a field-level pilot study to accurately assess the production in varying land and climatic conditions, to identify the right species, harmless methods of propagation of the plant, strict scientific studies to establish its economic viability in the long-term, and the emissions from its combustion.

— G M Pillai

Excerpted from The New Energy Economy, *edited by G M Pillai, published by World Institute of Sustainable Energy, 2005*

Is natural gas *the* fuel of the 21st century?

Natural gas is an efficient fuel, emits 60% less carbon dioxide than coal and 42% less than oil, and is available in abundance. But there are geopolitical, economic and infrastructural challenges in India's transition to a gas-fuelled economy

SUDHA MAHALINGAM

THE ONE GLIMMER OF HOPE on the energy horizon comes from a relatively new energy source — natural gas — hailed as *the* fuel of the 21st century. Natural gas emits 60% less carbon dioxide than coal and 42% less than oil for a comparable unit of consumption, although it does emit other non-carbon greenhouse gases. Gas is an efficient fuel and saves up to 30% of energy in most applications. Unlike nuclear energy, natural gas does not pose waste-disposal or safety problems. And it is available in abundance. If any single factor can substantially lower carbon intensity in the global economy, it is inter-fuel substitution or replacement of conventional fuels such as coal and oil by natural gas.

Yet, inter-fuel substitution is fraught with obstacles. Foremost among them is the location of global gas reserves. More than two-thirds of proven gas reserves in the world are clustered around the two oil-rich regions of Russia and the Persian Gulf, notably Iran and Saudi Arabia. Significant gas reserves are also found in Algeria, Indonesia, Trinidad and Tobago and Turkmenistan. China and India, which together account for a third of global incremental energy demand, have only modest gas deposits. Other major energy importers such as the United States, Europe, Japan and South Korea have either modest gas deposits or none at all.

The single most important factor that constrains more widespread use of gas is its lack of fungibility. Gas deposits occur independent of oil fields as well as part of them. The latter is called associated gas and it used to be flared until it was discovered to be useful as an independent fuel. Unlike oil, which can be stored and shipped to any destination in any part of the world, gas used to be treated as a stranded resource unless it had a use nearby and could be piped. Gradually, non-associated gas deposits acquired value, provided there was a ready regional market for them. With the advent of liquefaction, gas has acquired a degree of fungibility, though the high costs of liquefaction and regasification detract from its widespread acceptance. Even today, liquefied natural gas (LNG) accounts for no more than 6% of global gas trade. Gas is thus regarded as a regional resource.

For developing countries in pursuit of rapid electrification, gas presents an alluring prospect. Technological breakthroughs in combined cycle gas turbines have rendered gas-fuelled generation very efficient. Plants with such turbines can be set up in a short time and require much less initial capital investment than hydroelectricity or coal-fired power generation plants. Throughout the world, gas is fast replacing coal as the preferred power generation fuel. Gas also has applications in the manufacture of fertiliser. India, with its focus on food security, consumes 40% of its gas in the fertiliser sector. The Paris-based International Energy Agency predicts that by 2020 developing countries in Asia will increase their gas consumption by a factor of six. The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol are perceived to have key roles in facilitating the switch to cleaner gases.

Prospects for natural gas use in India

With 15% of the world's population, India has less than 1% of global gas reserves and depends on imports. Natural gas accounts for 8% of the country's energy basket. Apart from domestic production, gas is imported from Qatar in the form of LNG. About 40% of gas consumed in India goes to fuel gas-turbine plants generating power.

The challenges that confront India in its endeavour to transit to a gas-fuelled economy are three-pronged: availability, affordability and infrastructure.

The geopolitical challenge

India's gas deposits are found in Assam and Gujarat and offshore in south Bassein. At an annual production rate of around 1.024 trillion cubic feet (tcf), productive fields are expected to last 28 years. Until recently, it was believed that all the gas deposits in the country had been mapped and this belief shaped India's gas policies. However, recent offshore finds by both public and private sector investors in exploration have raised hopes that perhaps a significant portion of domestic demand could be met by indigenous production. But the deposits are deep and extraction could be both challenging and costly.

In any case, the growing demand for gas will necessitate continued reliance on imports. India is surrounded by gas-rich neighbours — Iran to the west, Turkmenistan to the north and Bangladesh and Myanmar to the east. Gas could be piped in from these countries and LNG imported from elsewhere. As of now, India does not import piped gas from anywhere, although it began importing LNG from Qatar in 2004. With the recent inauguration of the second LNG terminal at Hazira, India's LNG capacity has gone up. But either through pipelines or in the form of LNG, imports will have to satisfy the growing need for gas. Throughout the world, pipelines are the more convenient and economical mode of gas conveyance. Yet, geography and

geopolitics seem to frustrate India's efforts to access neighbourhood gas through pipelines.

Iran is home to the second largest gas reserves in the world, next only to Russia. The logical markets for Iranian gas would be India and China, since Europe is well supplied by Russia and Algeria. India's Ministry of Petroleum and Natural Gas has initiated measures to bring Iranian gas through a pipeline that will traverse 2,775 km, of which 760 km are in Pakistani territory — in the troubled Baluchistan province. The total investment in the pipeline project is estimated to be US$ 4.16 billion at current prices.

Yet, the Iran-Pakistan-India pipeline may remain a pipedream, not only because political differences with Pakistan defy resolution, but also because the new political dispensation in Iran seems to be heading towards a confrontation with Western powers that might eventually provoke UN sanctions against Iran, leading to an economic blockade. An undersea pipeline that might avoid the political pitfalls and carry the gas directly from Iran to India's western shores appears to be a tantalising, if expensive, prospect, but no feasibility study has been done so far. Whether under sea or over land, it is doubtful whether international investors would finance the construction of a pipeline originating from Iran.

Gas-rich Turkmenistan sits across the mighty mountain ranges that separate the Indian peninsula from its Central Asian neighbours. The 1,680 km pipeline will run through Herat and Kandahar in Afghanistan, the Pakistani cities of Quetta and Multan and on to the Indian border town of Fazilka. If it is to be extended to Delhi, it will have to run another 600 km. Construction costs are estimated at US$ 3.5 billion. In view of the costs, the challenges posed by the terrain, and the vulnerability of any pipeline on this route to potential terrorist attacks, there is little hope that it will be built in the near future.

Myanmar's offshore gas field Shwe 1 is estimated to have in place reserves of 4 to 6 tcf. Two Indian companies have a total of 40% equity stake in this field. This gas will have to cross either Bangladesh — which is reluctant to provide transit rights to India — or India's northeastern states of Manipur, Mizoram, Tripura and Assam before it reaches India's gas markets in West Bengal. The latter option is considered unattractive since the pipeline will have to cross ecologically sensitive areas and the distance is too long to make it economically viable.

As for Bangladesh, which may have up to 32 tcf of gas, political and public opinion seems to be overwhelmingly against exports to India. In the circumstances, India's prospects for accessing neighbourhood gas supplies through pipelines seem to be frustrated as much by geopolitics as by geography.

The affordability challenge

One way to overcome geopolitical challenges is to opt for LNG, but affordability could be a key challenge. LNG is an expensive option. Liquefaction requires gas to be cooled to 264°F. Liquefied gas has to be transported in cryogenic ships to markets where it has to be regasified. The process of cooling, transportation and regasification adds considerably to the cost

of delivering gas to markets. This, in addition to crude price linkage, renders the burner tip price of gas rather steep. Although improvements in technology in the past decade have brought down the cost of liquefaction by a third, soaring crude prices have taken the sheen off LNG.

Affordability is as vital a criterion for India as are availability and accessibility of adequate energy supplies. India's domestic gas production by state-owned companies is supplied to power and fertiliser plants at a subsidised rate. India's National Thermal Power Corporation, which ranks among the top 10 power generators in the world in performance as well as size, has set up seven gas-turbine power stations in the last decade. But, owing to non-availability of sufficient quantities of gas at an economical price, many of these stations are operating at sub-optimal capacity. In fact, the corporation has decided not to set up any more gas-based power stations and is now deviating from its core competence to build hydropower plants. Other gas-fuelled power developers in the country that do not get subsidised gas under the gas allocation mechanism have been forced to shut down their plants. Inter-fuel substitution away from polluting coal and towards clean gas is seriously constrained by the prevailing price of gas.

Gas is also unviable for the transportation sector in India. A few thousand public transport vehicles in the national capital were converted from diesel to compressed natural gas (CNG) some years ago, following an order from the apex court. However, large-scale transition to gas-fuelled automobiles will not occur unless gas is available at stable and affordable prices, and the necessary infrastructure is in place.

If the architects of the Kyoto Protocol are serious about combating climate change by promoting fuel-switching and appropriate technologies, it is imperative that Kyoto members collectively lobby to de-link gas prices from crude. Since gas replaces coal in most uses, it can be indexed to coal prices. Otherwise, developing countries will have no option but to turn to affordable energy supplies. Coal fits the bill nicely. It is abundantly available, especially in China and India, never mind if it emits carbon and contributes to global warming. The quest for growth will drive these countries to dip into their domestic coal reserves. For countries hamstrung by Kyoto commitments to reduce carbon, nuclear energy will provide an attractive alternative to gas. Global initiatives for combating climate change cannot ignore gas.

Falling off the map: Orissa's submerged villages

In 1930, land records show an area of 320 sq km for the Satabhaya cluster of seven villages near Paradip in Orissa. Land records for 2000 indicate that this area has been reduced to 155 sq km. Five of the seven villages have been swallowed by the sea. Several other villages in Orissa are likely to suffer the same fate. Are Orissa's coastal villages paying the price of global warming?

RICHARD MAHAPATRA

NATURE DOESN'T LIKE IMMORTALITY. Nigamanand Pradhan, an 11-year-old student in Kanhapur village in Orissa's coastal district of Kendrapara, realised that on September 18, 2005. His village, immortalised as the home of the fabled Tapoi, a folk character epitomising Orissa's glorious maritime trade history, will soon be wiped off the map of Orissa. And with it will go the last relic of Orissa's economic might; the state is now the poorest in India. It was the night before September 18 that Nigamanand's father had told him that the Tapoi story in his school textbook was set in his village.

Nigamanand, who dreamt all night long about his village's unforgettable past, rushed to school early the next morning to share this piece of history with his friends. "My school had just vanished into the sea. I could only find the blackboard that had been swept to shore half-a-kilometre from the village," he says. As his parents prepare to shift their home, now just 50 metres from the violent Bay of Bengal, they tell Nigamanand: "For the third time we are shifting away from the sea. The original location of the village is some 1 km inside the sea."

Within three months, the sea has swallowed up the village school, its rice-processing factory and a few metres of precious agricultural land. The ruins of the rice-processing factory can still be seen when the sea is calmer in the late-afternoon.

Benudhar Pradhan, Nigamanand's father, says: "The sea, a distant dream 50 years ago, is now a real nightmare."

Going by the residents' calculations, the sea will consume all of Kanhapur within a few years. "We don't have any option now but to migrate," says Pradhan. The 500-odd residents of the village agree.

Indeed, the sea has already encircled the village on three sides. One can judge its progress by the fact that five of the six tubewells set up at regular intervals along the village's main street are submerged. During high tide, the water comes close to the single tubewell left; the well remains a gauge post by which the villagers measure the sea's incursions. Just a year ago, one of the tubewells could be seen half-submerged in the sea. Now it is no longer visible.

Five years ago, Nalinikant Biswas' house was on Kanhapur beach. Even today, during low tide, he can see the foundations of his mud home. Biswas had 4 acres of fertile land, enough to lead a comfortable life. Now, with just 1 acre of land, he has decided to quit farming. "My land is totally saline due to seepage of seawater. In the last two years I earned a meagre two quintals of paddy," he says.

The constant threat of a rising sea is forcing him to move out. But where to? "I don't have the money to buy land and I'm not sure whether I can further encroach land as it is part of the national park," he says. Biswas' future is as uncertain as the sea.

Just a kilometre away is Satabhaya village. Nigamanand Rout, the 40-year-old sarpanch of the village, who also represents Kanhapur village, is puzzled. His village has shifted four times in the last three decades to maintain a safe distance from the marching sea. "The sea level is rising, taking away one village after another. My tenure will end in three years. I am not sure whether my constituency will exist at that time," he says.

Rout has been fighting two unmanageable players: the rising sea and a government that barely acts. "I am slowly reconciling to the fact that our existence is doubtful. But why is the sea rising? I should know the reason so that other villages can be saved," he says.

The Satabhaya region, once a cluster of seven villages, is located some 25 km from the port of Paradip, at the confluence of the Mahanadi and Brahmani rivers. One has to walk 10 km from the nearby small town of Gupti, criss-crossing crocodile-infested mangroves, to reach the villages that are situated inside the Bhitarkanika National Park, famous for mass nestings of the Olive Ridley turtle.

As night descends, the 1,000 people left in the remaining two villages live with the ever-present fear that the sea will come and grab their last chance of survival. During the late-1990s, the population of the two villages was around 3,000, but most people have moved out after losing their lands to the sea. "People are so scared of the sea that even a high tide triggers panic," says Rout.

The two villages are only five metres away from the sea during high tide. "Every day we lose a few things," says Mahendra Biswal, a 65-year-old farmer in Satabhaya. "Since the 1980s we have been fighting constant rises in sea level. I don't even remember exactly where my home was located. It is now somewhere inside the sea."

According to local residents, the sea has advanced around 2.5 km in the last 15 years. Earlier, people lost their houses and were forced to move to their agricultural lands that stayed fallow due to excess salinity.

The surge

For 25 years, this patch of the Orissa coastline has been witnessing significant rises in sea level. Of the seven villages that formed the Satabhaya cluster, five have ceased to exist. The sea has swept inland by 2.5 km. "I visited the area two years ago and could see a few buildings and tubewells half-submerged in the sea. Now nothing is visible," says Ashis Senapati, district reporter of *The Times of India* and a local resident. Several years ago, the palace of the erstwhile king of Kanika was still visible from the shore, a few metres inside the sea; today, people are unsure about its exact location. G K Pujari, a scientist with Orissa's environment department, says: "One thing is certain, the sea level is rising here, therefore the quick ingression."

The first villages to vanish into the sea in the early-1980s were Govindpur, Mahnipur and Kuanriora. Then, in the mid-1990s, two more villages — Kharikula and Sarpada — were submerged. Now, besides Satabhaya and Kanhapur, 18 other villages along the coast are at risk. Most have barely 40-50% of their lands intact.

Constantly pushed back by the sea, the local residents find themselves in a unique situation: technically they are encroachers as their legal documents show their lands are somewhere inside the sea. In fact, the government still asks for land revenue and the villagers pay it to maintain their legal status.

Dilip Kumar Manda, who has settled in Okilpara village, some 15 km away from Satabhaya, used to be a resident of the now non-existent village of Govindpur. As he accompanies me to Satabhaya, he tells me what it used to be like all those years ago.

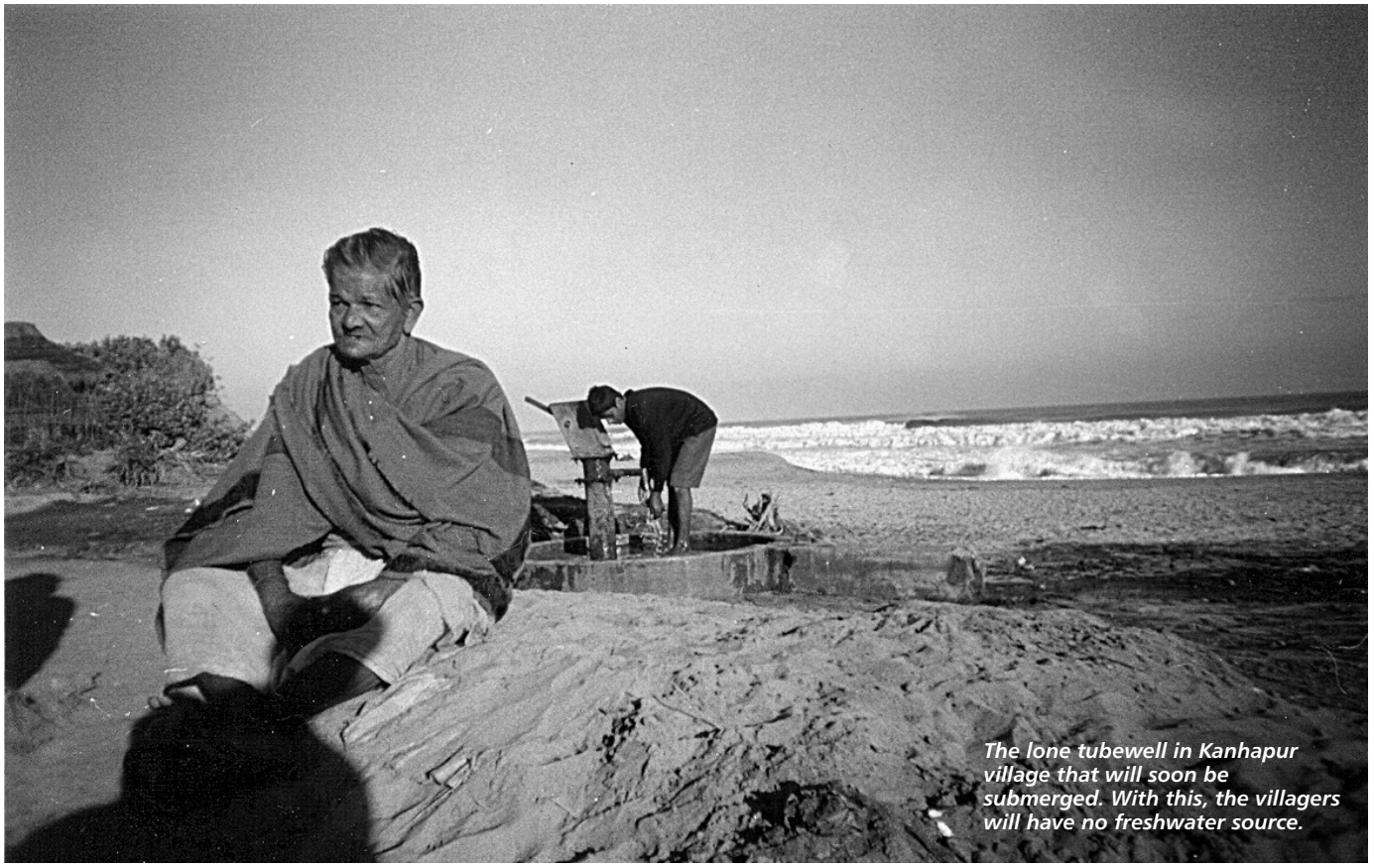
"As a kid I used to take five hours to go out to sea and come back home," he says. Govindpur was a prosperous village of around 500 people, located some 2 km from the sea. Dilip's parents shifted three times before migrating out of the village. "We lost everything, from our home to our agricultural lands to our livelihood. Nobody had any idea why the sea was rising," he recalls.

After the 1971 cyclone, three villages in Satabhaya — Govindpur, Mahnipur and Kuanriora — started losing their battle with the sea. For five years the water advanced so much that by 1976 the three villages were deep inside the sea. Many of the villagers resettled on government land near the sea. But the sea continued its rampage; by 1985, the displaced villagers were temporarily settled some 4 km from their original villages. Finally, during 1986-88, they migrated to other areas.

According to Dilip, people from his village and from Mahnipur settled in an open field that has now become Okilpara village. Okilpara, as the last refuge against the rising sea, still receives settlers from Satabhaya and Kanhapur.

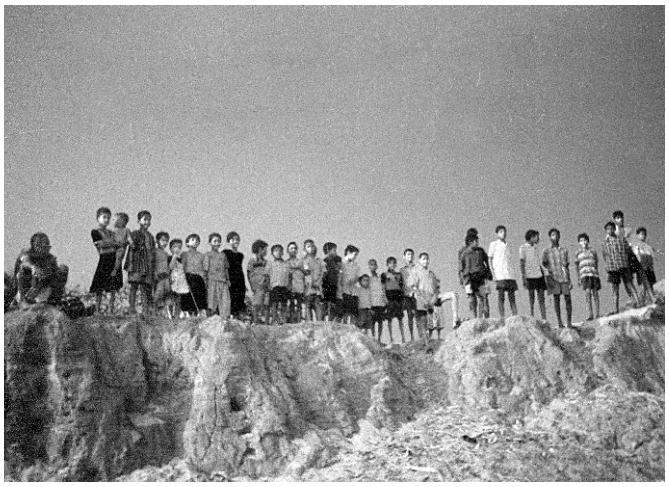
The same story was repeated after the 1982 cyclone when rising sea levels submerged the villages of Kharikula and Sarapada. In just three years these two villages of around 1,800

Richard Mahapatra



The lone tubewell in Kanhapur village that will soon be submerged. With this, the villagers will have no freshwater source.

Richard Mahapatra



Children stand at the place where their school once stood, in Kanhapur village.

people were swept off the face of the earth. There is barely any information about who went where, although some people settled in Okilpara.

They may just be the lucky few survivors!

Falling off the map

Mohan Pradhan, a land surveyor (called *amina* in the local language), looks grave as he dusts off old records in the dilapidated tehsil office in Gupti. He insists that most of the villages I mention have vanished. He rolls down two hand-drawn maps, one of 1930 and another of 1990 (land records are prepared every 50 years). The last land survey was released in 1990 after the process was completed in 1988.

There is a stark difference between the two maps: in the 1990 map, the Bay of Bengal has moved significantly inland. "That is the area under the sea at that time. You have visited the area now so you have seen how much more has gone inside the sea," he says. In the 1990 records, the government showed that all seven villages suffered high levels of sea erosion. But it didn't mention total submergence. By 1999, the tehsil department had regrouped the villages: officially, Satabhaya and Kanhapur now exist as one panchayat. In 1930, the Satabhaya cluster of seven villages had an area of 320 sq km; in 2000 it is shown as just 155 sq km. The 1990 map clearly shows that 18 other villages along the coast in the same region suffer sea erosion. Of them, three villages — Badagahirmatha, Sanagharimatha and Sahebpur — are already inside the sea. Residents of these villages have resettled in a nearby casuarina forest.

People's perceptions and scientific projections

As village after village in Orissa's coastal Kendrapara district vanishes into the Bay of Bengal, one thing is clear: sea levels are rising. Why is this happening?

Many say these villages, which themselves have virtually zero emissions of greenhouse gases, could be paying the price of global warming. The local people blame climate change for changes in the sea level. This correspondent interviewed about 70 residents of Satabhaya and Kanhapur villages near the port of Paradip. They all felt that the local climate has indeed changed and that rising sea levels are a result of increasing sea temperatures. Importantly, people also link higher temperatures to the increasing number of low-pressure areas in the Bay of Bengal. One trend clearly emerged: higher sea temperatures are causing more cyclonic conditions and, as a result, rising sea levels.

"There is a sharp increase in the number of low-pressure areas in the Bay of Bengal. Just a decade ago it was not that frequent," says Sukhadeva Parida, a resident of Kanhapur. In fact, during 2005, the Bay of Bengal witnessed 10 low-pressure phenomena, six of which were in the post-monsoon period of October-December. The locals believe that the increase in the number of low-pressure phenomena is aggravating coastal erosion in their villages. "Low pressure often triggers huge tidal waves that take away our villages," says Nalinikant Biswal of Satabhaya village. The intensity of cyclones, in terms of wind speed and severity, has also increased; the 1999, 1982 and 1971 cyclones battered villages along the coast. People say that after each cyclone the sea level rose significantly and the submergence was quicker. They also say that there are more low-pressure conditions, often after the monsoons.

Another important perception is that overall temperatures are rising, and that low-pressures are directly linked to rising sea temperatures. Budha Charan Behera, 90, the oldest resident of Satabhaya, says: "Summer days are more now, and one can easily feel the warmer seawater. My father used to tell me that when the temperature of the sea rises, cyclones happen. For the first 60 years of my life I saw only one cyclone and very few low-pressure situations. Now, they happen almost every month. That is the reason the sea is rising." Sixty out of the 70 people interviewed agreed with this point.

The scientific community studying Orissa's tryst with disasters stands polarised on the issue, although most do somewhat hesitantly blame global warming for rising sea levels. "This phenomenon may well be the preliminary impact of global warming-induced sea level rise. Going by simulated models of the impact of climate change on the Indian coast, this is one of the most probable impacts," says Dr Murari Lal, a coordinating lead author of the Intergovernmental Panel on Climate Change (IPCC), a global body of scientists studying climate change. Lal, an atmospheric scientist, has extensively studied the impact of climate change in India. He says that, given Orissa's geographical location at the head of the Bay of Bengal, a landlocked sea, and the state's deltaic plain character, Orissa's coast is extremely vulnerable to rises in sea level. "My calculations and research show that the phenomenon is a direct impact of climate change induced by global warming," he says.

For years, environmentalists have warned that one of the first and most reliable signs of global warming-induced climate change would be an upsurge in violent cyclones, like the Orissa cyclone of 1999. Global warming, in theory, exacerbates cyclonic conditions such as low-pressure phenomena. Warmer air easily translates into warmer oceans — and warm oceans are the perfect trigger for low-pressure conditions and, consequently, severe cyclones. A statistical analysis of 98 years

(1891-1988) has revealed that global warming in the present century is linked with the increasing frequency of pre- and post-monsoon cyclones in the Bay of Bengal. On the other hand, during the monsoon, cyclones have become less frequent, according to the Indian Institute of Tropical Meteorology, Pune. However, post-monsoon cyclones/low-pressure phenomena have increased, indicating a warmer sea.

Going by the Indian Meteorological Department's cyclone statistics for 1877-1990, the Orissa coast has been hit the hardest. Of the 964 cyclones that crossed the east coast during this period, 422 struck Orissa.

It is almost certain that an increase in sea surface temperature will be accompanied by a corresponding increase in cyclone intensity. Recent studies suggest a possible increase in cyclone intensity of around 10-20% for a rise in sea surface temperature of 2-4 degrees Centigrade. In low altitude and landlocked locations, such as the Bay of Bengal, tropical cyclones are the major cause of storm surges. Amplification in storm surge heights result from the stronger winds and low pressure associated with more intense tropical storms. Thus, an increase in sea surface temperature due to climate change should lead to higher peaks of storm surges and greater risk of coastal disasters along the east coast of India, as a result of rising sea levels. The Satabhaya situation looks a lot like this.

Warmer seas also trigger a phenomenon called thermal expansion. Scientifically, when any liquid heats up, its volume expands. In the case of the sea — a massive store of liquid — rising surface temperatures lead to expansion thus causing sea levels to rise. But the most popular reason for sea level rises in a warmer world is that ice stores like glaciers melt faster, adding to the water in the sea. "The Bay of Bengal is showing these symptoms at a preliminary level," says Pujari. "Sea temperatures are rising for sure. That means it is under thermal expansion. That could well explain the Satabhaya phenomenon," says Lal. According to him, global warming will manifest in similar local changes.

Estimates of rising sea levels during the 20th century rely on tide-gauge data and the recent satellite altimeter data. Global sea levels are estimated to have risen by 10-25 cm over the last 100 years (IPCC, 2001). There has, however, been no detectable acceleration of rises in the 21st century. Projections based on Coupled Atmospheric Ocean Global Circulation Models (AOGCMs) for scenarios of future concentrations of GHGs over the period 1990-2100 suggest that global mean sea levels could rise by 0.09-0.88 m as a result of thermal expansion and the melting of glaciers and polar ice.

India is one of the 27 countries most vulnerable to rising sea levels, according to a 1989 United Nations Environment Programme assessment. There have been few studies that have explored the impact of rising sea levels on India. One of the first studies was carried out by the Jawaharlal Nehru University (1993), in which the consequences of a 1 metre rise in sea level were evaluated. The study concluded that, in the absence of protection, approximately 7 million people would be displaced and 5,764 sq km of land and 4,200 km of roads would be lost.

The dominant cost estimated was due to loss of land, accounting for 83% of all damage. A subsequent study by the Tata Energy Research Institute (1996) explored the relative vulnerability of various coastal regions including the Orissa coast, the effects of adaptive responses to the impact of rising sea levels, and the value of coastal protection for selected regions.

Future climate change and estimated rising sea levels in the Indian coastal zone, based on past observations on mean sea levels along the Indian coast, indicate a long-term rising trend of about 1.0 mm/year on an annual mean basis. However, recent data suggests a rising trend of 2.5 mm/year in sea levels along the Indian coast. The oceanic region adjoining the Indian subcontinent is likely to warm up on the surface by about 1.5-2.0 degrees Centigrade by the middle of this century, and by around 2.5-3.5 degrees Centigrade by the end of the century. The corresponding thermal expansion-related rise in sea level is expected to be in the range of 15-38 cm by the middle of this century and 46-59 cm by the end of the century.

According to the National Institute of Oceanography, Goa, which monitors sea level rises along the Indian coast, in a study of 24 stations during 1878-1994, the sea level computed for 11 stations out of the 24 showed rising sea levels at 5% level of significance. The only exceptions were two stations in Vizag and Chennai.

Rises in sea level at a particular location are the combination of global rising sea levels and local trends. It is expected that global sea levels will rise between 9-88 cm by 2100, according to IPCC, 2001. However, in many coastal regions, local factors often dominate the global signal. Therefore, while assessing the impact of rising sea levels it is important to account for long-term local sea level trends. The IPCC has estimated that an increase of 0.5 degrees in temperature will raise sea levels by 10 cm in a study in the Sunderbans. Satabhaya has a similar topography but does not have mangroves; it therefore suffers greater inundation.

Back in Kanhapur village no new school has come up. It has been over three months since the children stopped going to school. The sarpanch says the government is not willing to invest money in a place that will be washed away in a few years. Local administrative officials refuse to speak, as the situation continues to baffle them. "We don't know why the sea is rising. So there is no need to speak," was the prompt reply of one senior district official.

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Climate change timeline

1827: French polymath Jean-Baptiste Fourier predicts an atmospheric effect keeping the earth warmer than it would otherwise be. He is the first to use a greenhouse analogy.

1890s: Swedish scientist Svante Arrhenius and an American, P C Chamberlain, independently consider the problems that might be caused by CO_2 building up in the atmosphere. Both scientists realise that the burning of fossil fuels could lead to global warming, but neither suspects the process might already have begun.

1890s to 1940: Average surface air temperatures increase by about 0.25°C.

1957: US oceanographer Roger Revelle warns that humanity is conducting a "large-scale geophysical experiment" on the planet by releasing greenhouse gases. Colleague David Keeling sets up first continuous monitoring of CO_2 levels in the atmosphere. Keeling soon finds a regular year-on-year rise.

1979: First World Climate Conference adopts climate change as a major issue and calls on governments "to foresee and prevent potential man-made changes in climate".

1985: First major international conference on the greenhouse effect at Villach, Austria.

1988: Global warming attracts worldwide headlines after scientists at Congressional hearings in Washington DC blame major US drought on its influence. Meeting of climate scientists in Toronto subsequently calls for 20% cuts in global CO_2 emissions by the year 2005. UN sets up the Intergovernmental Panel on Climate Change (IPCC) to analyse and report on scientific findings.

1990: The first report of the IPCC finds that the planet has warmed by 0.5°C in the past century. IPCC warns that only strong measures to halt rising greenhouse gas emissions will prevent serious global warming.

1992: Climate Change Convention, signed by 154 nations in Rio, agrees to prevent "dangerous" warming from greenhouse gases and sets initial target of reducing emissions from industrialised countries to 1990 levels by the year 2000.

1994: The Alliance of Small Island States — many of which fear they will disappear beneath the waves as sea levels rise — adopt a demand for 20% cuts in emissions by the year 2005. This, they say, will cap sea-level rise at 20 centimetres.

1995: The hottest year recorded to date. In March, the Berlin Mandate is agreed by signatories at the first full meeting of the Climate Change Convention in Berlin. Industrialised nations agree on the need to negotiate real cuts in their emissions, to be concluded by the end of 1997. In November, the IPCC states that under a "business as usual" scenario, global temperatures by the year 2100 will have risen by between 1°C and 3.5°C.

1996: At the second meeting of the Climate Change Convention, the US agrees for the first time to legally binding emissions targets and sides with the IPCC against influential sceptical scientists.

1997: Kyoto Protocol agrees legally binding emissions cuts for industrialised nations, averaging 5.4%, to be met by 2010. The meeting also adopts a series of flexibility measures, allowing countries to meet their targets partly by trading emissions permits, establishing carbon sinks such as forests to soak up emissions, and by investing in other countries. Meanwhile, the US government says it will not ratify the agreement unless it sees evidence of "meaningful participation" in reducing emissions from developing countries.

1998: Follow-up negotiations in Buenos Aires fail to resolve disputes over the Kyoto 'rule book', but agree on a deadline for resolution by the end of 2000. 1998 is the hottest year in the hottest decade of the hottest century of the millennium.

2000: IPCC scientists re-assess likely future emissions and warn that, if things go badly, the world could warm by 6°C within a century. A series of major floods around the world reinforce public concerns.

2001: US President Bush renounces the Kyoto Protocol because he believes it will damage the US economy. Talks in Bonn and Marrakesh finally conclude the fine print of the Protocol. Analysts say that loopholes have pegged agreed cuts in emissions from rich-nation signatories to less than a third of the original Kyoto promise. Signatory nations urged to ratify the Protocol in their national legislatures in time for it to come into force before the end of 2002.

2002: Parliaments in the European Union, Japan and others ratify Kyoto. But the Protocol's complicated rules require ratification by nations responsible for 55% of industrialised country emissions, before it can come into force. After Australia joins the US in reneging on the deal, Russia is left to make or break the treaty, but hesitates. Meanwhile, the world experiences the second hottest year on record.

2003: Globally it is the third hottest year on record, but Europe experiences the hottest summer for at least 500 years, with an estimated 30,000 fatalities as a result. Extreme weather costs an estimated record of $ 60 billion this year.

2004: A deal is struck on Kyoto. President Putin announces in May that Russia will back the Protocol, and the EU announces it will support Russia's membership of the World Trade Organisation. On November 18, the Russian parliament ratifies the Protocol, paving the way for it to come into force in 2005.

2005: Second warmest year on record. Researchers link warming to a record US hurricane season, accelerated melting of Arctic sea ice and Siberian permafrost, and apparent disruption of the global ocean current that warms Europe. The Kyoto Protocol comes into force. In December, Kyoto signatories agree to discuss emissions targets for the second compliance period beyond 2012, while countries without targets, including the US and China, agree to a "non-binding dialogue" on their future roles in curbing emissions.

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