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A Case Study in Energy Planning Taking Account of Environmental Considerations

Energy Efficiency in India

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I. Introduction

The Task Force on India's Medium Term Energy Strategy, established by the Planning Commission, was holding its first meeting in New Delhi on a crisp morning in early January. There was an hour's delay by the time everyone had arrived and the meeting could start. The Chairman, Professor Bhojedhur, a world-renowned physicist, had arrived early and was looking out of the window of the Ministry building in one of the city's older quarters, with beautifully manicured lawns, wide avenues, and relatively little traffic — only the occasional 'Hindustan' taxi or official car. "What an oasis of calm in a city of chaos," he thought to himself. The building was a turn-of-the-century Lutyens-designed government office block in Rajastan stone, in an enclave with restricted entry to the public and no entry for rickshaws, vendors and other rif-raf. How different from where the Professor lived, just off the Ring Road. The traffic there was continuous and the large houses running along the highway — built in the early 1950s and already showing signs of their age — were crowded together.

New Delhi had gone through a metamorphosis in the 45 years since independence.

The city had gone through a metamorphosis in the 45 years since independence, from a small administrative capital with less than half a million people to a megalopolis of over 10 million. Travel time was continually increasing as 500 new cars or scooters were added to the roads daily with no discernible increase in road space. The city's burgoning middle class was complaining about the air pollution. Two NGOs had taken up the cause, drawing on a wealth of statistics to show that respiratory ailments in the city were 12 times the national average, and that measurements of air quality violated the country's ambient air quality standards for SO_2 and NO_x in some locations in the winter months, and for dust or suspended particulates throughout the year. The clamor for some action was getting very vocal. (Further information on air pollution in New Delhi is provided in the appendix.)

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Although the plight of the capital city was on Professor Bhojedhur's mind, so was the realization that there were many other cities in as serious condition, or perhaps even worse. The press in Bombay, Calcutta, and Madras frequently drew their readers' attention to the over-attentive treatment received by Delhi. Action to improve traffic flow and air quality in the capital without doing something in the other metropolitan areas would not be kindly received. Yet, to take measures to satisfy everyone was impossible, as Professor Bhojedhur knew only too well.

These environmental problems were only one facet of a whole host of issues related to the country's development and its use of energy. When India began its program of industrialization in the hopeful years after independence, with the initiation of the Five Year Plans and the guiding *dirgiste* philosophy of Prime Minister Nehru, the focus was on building a domestic industrial home base, using domestic energy — principally coal and hydro power, of which there was no shortage. As industry grew, as domestic incomes rose, and as the population expanded the country's energy needs rapidly multiplied.

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Although there was no shortage of basic minerals and renewable sources, there was a deficiency of useful delivered energy, principally in the form of electricity. It cost a great deal to build the infrastructure, and the pressure on the competing funds was always there. Industry complained that it had to invest in expensive private energy generation to ensure a reliable supply. Domestic consumers complained that there was not enough electricity available — especially in the hot months, when a fan becomes a necessity and an air-conditioner is something high on the list of priorities for even the most modestly paid professional class. In spite of the shortage in supply, delivered energy growth rates remained impressive. Since the 1960s, electricity consumption had grown at an annual rate of 8 percent, petroleum products consumption at a rate of 5.8 percent, and coal consumption at 5.6 percent. With the power of compounding, this meant that consumption of electricity had gone up nearly five-fold and coal and oil consumption three-fold between 1960 and 1990.

Discontent with the quality of life was being voiced by the growing middle class.

In more recent years, other issues had come to the forefront. At home, the discontent with the quality of life was being voiced by the growing middle class, estimated at between 60 million and 100 million. Principally, the complaints involved road traffic and air pollution, which affected daily life and from which there was no easy escape. But there was also pressure to protect the interests of the poor, especially where energy developments involved displacement of populations. Internationally, energy had become a political issue with the emergence of the Greenhouse Effect. The impact of continuing on a 'Business as Usual' path across the whole globe would be to raise mean global temperatures by between 1.5 and 4.5 degrees centigrade by the year 2050. The sea level rise and the changes in climate patterns associated with that would be sufficient to cause serious problems, especially in low-lying areas and the tropical and sub-tropical belts. To arrest this phenomenon (it cannot be totally avoided, due to the built-up

pressures for global warming from the existing accumulation of greenhouse gases), a number of proposals had been made. None had universal agreement, but the developed countries were acting broadly to keep CO_2 emissions at their 1990 levels by the year 2000 or 2005. Some were even planning to reduce emissions relative to 1990 levels by 2005. The developing countries (such as India) had no commitment to a target, but the declaration at UNCED required them to take such measures as they could to reduce CO_2 emissions without jeopardizing their prospects for development. Some funds were available through a World Bank operated window called the Global Environment Facility to assist in measures to reduce greenhouse gas emissions. The principle gas is CO_2, responsible for two-thirds of the warming impact, but there are others — namely methane, nitrous oxide, and CFCs. As an important player among the family of nations, India wanted to undertake actions in keeping with the declaration of the Earth Summit. At home, however, this issue was by no means one on which there was agreement. NGOs, such as the Forum for Environmental Equity and Trust (FEET), led by activist Nial Rawal, had argued that *any* action by India was tantamount to environmental imperialism — when a country that had not been responsible for the present crisis was being asked to make sacrifices in order to help resolve that crisis.

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In response to these pressures, the government of India set up the Task Force to examine options for changes in environmental policy and to make recommendations to deal with national and international issues. The Task Force had a budget to subcontract research papers and to call experts to give evidence. It had to make some recommendations within six months, but could specify a more detailed set of actions on the basis of a longer period of deliberation. The Task Force was to complete its work within eighteen months. Its findings would be made to the Planning Commission, which would then prepare a paper to be discussed in the Cabinet and from which an action plan would be formulated. There were ten members on the Task Force, drawn from industry, the NGOs, academia, and the government sector. There was a well equipped Secretariat at its disposal and a generous travel budget.

The government set up the Task Force to examine the options for changes in environmental policy.

At its first meeting the Task Force set up a series of public meetings in seven cities, at which selected individuals would be invited to offer their opinions. In addition, it offered a contract to a well established institute — the Centre for Energy, Environment, and Development (CEED). The Task Force asked the institute to examine the environmental implications of a business-as-usual (BAU) scenario and to look at two other scenarios in some detail. The first scenario gave greater importance to energy conservation, and the second emphasized the development of renewable domestic energies. In neither case was it to be assumed that growth in GDP could be sacrificed to any change in environment policy. As a result, the growth/environment trade-off was not an issue. The brief of the study was to evaluate the technical options that would be involved, the costs associated with those options, and an evaluation of which was more attractive.

Questions for Discussion

(1) Is this a reasonable framework within which to address the issues? How would you add to/amend it?

(2) How would you modify/amplify the terms of reference of the main study that the task force has commissioned?

II. The Report Prepared by CEED

CEED delivered its Report to the Task Force on time. It was an impressive piece of work, running to three volumes with an executive summary. The latter laid out the methodology and main findings quite clearly. The scenario approach had been taken and two scenarios developed. In the first, the underlying growth in the economy (GDP) was held at five percent per annum, and in the second at six percent per annum. The first section of the report dealt with the demand for energy, the second with the supply, and the third with the environmental consequences.

A. The Demand for Energy

The demand for energy was driven by the assumed growth in GDP, but technical factors determined the demands for individual fuels. In agriculture, the demand for energy came from the demand for irrigation and for land preparation (land tractors). Technical coefficients determined the demand for energy given the area under irrigation, the crops grown, and the number of tractors. In industry, eight sectors were looked at. The demand in each sector was determined by the growth in demand for that sector's output and the technology assumed to be in operation. Some changes in technology were allowed for, where modifications in technology could be predicted.

In the transport sector, the demands were given by the projected total traffic and the relative shares of road and rail that would carry that traffic. For passengers, the share that would go by rail was expected to drop from 20 percent at present to 13 percent by 2010. For freight traffic, it was estimated to drop from 48 percent now to 35 percent in 2010. Within each mode, energy demand was estimated using technical parameters.

Household demand for energy was estimated from the current differences in use between the different income strata of society, and then extrapolated into the future so that a person earning 5,000 Rs per month in the year 2000 would consume the same energy (and energy mix) as someone earning 5,000 Rs per month now. The increase in family incomes were based on the GDP assumptions and the assumed growth in population.

Finally, although the model had calculated the demand for electricity as an end use fuel in the sectors defined above, a separate exercise had to be conducted to work out what fuels would be needed to generate that electricity. That involved running a least-cost dynamic programming model, which selected the combination of plants and fuels based on minimizing the capital and running costs of meeting a given demand for electricity.

The model predicted a growth in demand of energy for all fuels — except gas — of about 6 percent per annum if the assumed GDP growth rate was taken as 5 percent. Gas demand grew at 9 percent. For the higher GDP growth scenario of 6 percent, demand for energy other than gas grew at 6.5 to 6.9 percent, and the demand for gas grew at 9.5 percent. Although these were slightly lower than the historic rates, they represented a considerable demand in terms of resources to develop them, as can be seen below.

B. The Supply of Energy

CEED went on to look at how this demand might be met. For the BAU scenario it prepared the following investment profile, based on what it believed would be available for energy investments if the economy grew as it was predicted to. Thus, coal mining and oil exploration and development were limited by the available resources. The gas development was based on what would be demanded under each scenario. Inevitably, it was expected that domestic sources would not be able to meet the demand for energy and that therefore some fuels would have to be imported. CEED reported the 'cost' figures set out in Table 1 for the scenarios. The figures above the dotted line were based on investment costs alone, whereas those below the line included the costs of infrastructure investment (e.g., expanded port facilities for imports) and investment in private generation (for power supply), as well as the costs of the fuels themselves.

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Table 1
Economic Costs of Energy Supply in the BAU Scenario
($mn 1991 Prices, Discounted at 12%)

	Low GDP Growth Case	High GDP Growth Case
Coal mining	10,809	10,809
Lignite mining	671	671
Hydrocarbon exploration	27,645	29,023
Hydrocarbon development	5,477	5,963
LPG extraction	220	289
Natural gas development	3,294	3,834
Power supply	52,772	58,888
Power shortages	1,556	893
Fuel imports	23,284	32,429
TOTAL	128,421	145,538

The ECS presented measures to increase the efficiency of energy use and reduce efficiency losses in generation.

The AES presented measures such as using compressed natural gas for city transportation and development of wind farms and small hydros for electricity.

C. Alternative Scenarios

The alternative to a BAU scenario was considered to be either an Energy Conservation Scenario or an Alternative Energy Scenario. The differences between the BAU and these scenarios is summarized in Table 2 (facing page). It can be seen that the major differences for the Energy Conservation Scenario lay in the measures to increase the technical efficiency of energy use in industry, transport, households, and agriculture, as well as reducing efficiency losses in generation. The Alternative Energy Scenario introduced programs for compressed natural gas for city transportation, increased use of solar cookers and biogas plants, and development of wind farms and small hydros for electricity. The cost implications of these scenarios were examined and are summarized in Table 3.

Thus, the savings in the Energy Conservation Scenario were significant, whereas the Alternative Energy Scenario came up with slightly higher costs, of about one billion dollars in present value terms. The cost-savings comparison looked at the savings in fuels and reduced demands for investment in traditional energy supply sectors, on the one hand, against the costs of the measures themselves, on the other. Referring to Table 2, for example, CEED calculated the cost of the capital equipment required to achieve the increased efficiency in industry, the increased cost of improved road efficiency, and the introduction of a rail system in the urban areas, the retrofitting of agricultural pumps, etc. It did not include any cost for the increased efficiency arising from better operating practices.

On these grounds CEED argued that the case for the Energy Conservation Scenario was strong even if one did not allow for the increased efficiency through better operating practices.

Table 3
Economic Costs of Energy Supply in the Conservation and Alternative Energy Scenarios
(% Reduction in Costs Relative to High GNP Growth Case BAU)

	Energy Conservation	Alternative Energy
Coal mining	0	0
Lignite mining	0	0
Hydrocarbon exploration	0	0
Hydrocarbon development	0.03	-0.01
LPG extraction	0	0
Natural gas development	12.7	-16.9
Power supply	18.6	-3.2
Power shortages	48.2	35.9
Fuel imports	65.1	6.6
TOTAL ($MN 1991)	28,962	-1,018

Table 2
Proposed Alternative Strategies for India

Energy Conservation Measures

Demand Side Measures

Industry
- Energy conservation in the steel, cement, chemical, and petrochemical industries.

Transport
- Shift from road to rail transportation.
- Road improvements.
- More efficient buses.
- Urban rail transport system for Delhi, Madras and seven other cities.

Domestic Sector
- Improve the efficiency of LPG, kerosene, and soft coke stoves.
- Replace one-half of incandescent bulbs with flourescent tubes.
- Increase efficiency of air conditioners, fans, and refrigerators through proper maintenance.

Agriculture Sector
- Retrofit pumpsets.
- Encourage use of drip irrigation for sugarcane, cotton, and oilseeds, and sprinkler irrigation for maize and grain.

Supply Side Measures

- Reduction in transmission and distribution losses of electricity generation.
- Use of coal washeries for non-coking coal to reduce ash content for thermal power generation.

Alternative Energy Strategy

Demand Side Measures

Transport Sector
- Investment in compressed natural gas as a transportation fuel for cities close to existing gas pipeline network.

Domestic Sector
- Increase use of solar cookers.
  Further development of biogas plants and use of biogas cooking stoves.

Supply Side Measures

- Augmentation of power-generating capacity through renewable energy technologies: 3,000 MW windfarms; 1,500 MW small hydro.

More seriously, *all* indicators of environmental air quality are likely to decline by 2010.

D. The Environmental Implications

Table 4 gives the main environmental indicators that were calculated for the three scenarios, as well as a number of other key indicators. The BAU figures are for the 5 percent GDP growth scenario. The projections are based on India's per capita income going up from $350 to $650 in 2010 — somewhere around the level of Egypt or the Philippines today. Energy per unit of GDP remains high, however, by international standards. For example in 1990 the figures in middle-income countries varied from around 0.25kg/$ in Thailand to 0.41kg/$ in Malaysia. In developed countries the figures tend to be lower. In Japan it is only 0.14kg/$, and in the US, which is known for its high energy consumption, it is 0.30kg/$. There are, however, great variations between countries. Egypt currently has a value of nearly 1kg/$, whereas the Philippines has a value of only 0.29kg/$.

More seriously, the table shows that *all* indicators of environmental air quality are likely to decline by 2010. With BAU, SO_2 emissions would increase by 400 percent and particulates would increase by 470 percent. Even with the Energy Conservation Scenario, there are increases of 150 per cent and 210 percent respectively.

Questions for Discussion

How would you respond to the following assumptions in the analysis:

a. The underlying growth projections?
b. The demand for energy projections?
c. The calculations of the costs of supply for the BAU?
d. The definition of the alternative scenarios?
e. The valuation of the costs of the alternative scenarios?
f. The feasibility of the alternative scenarios?
g. The information supplied on the environmental and other impacts?

Table 4
Summary Results from the CEED Study

		Total Figures in 2010 with 5% GDP Growth		
Key Indicators	1989/90	BAU	Energy Conservation	Alternative Energy
Population (10^6)	829	1,211	1,211	1,211
GNP ($\$10^9$)	295	783	783	783
Energy/GDP (kgoe/$)	0.56	0.68	0.56	0.68
Key Emissions (Mn.T.)				
CO2	192	488	263	488
SO2	2	10	5	10
Particulates	41	234	127	234

III. Discussion of the Report

The meeting of the Task Force to discuss the preliminary report took place in early July. The monsoon had not yet arrived, and the temperature was over 40° centigrade in the shade by midday. All too aware of the frequent power outages, Professor Bhodejur had arranged the meeting to start at 7:30 a.m., hoping to avoid the worst of the heat. He asked each member of the task force to give their opinions.

The first to speak was **Mr. Jajab**, the well-known industrialist. He first pointed out the importance of industry in the economy, and the priority given to industrial development in India's post-independence history. The energy needs of industry and households were underestimated in his view. "How can a growth rate of delivered energy of six percent suffice when eight percent had been the rate of growth for the past 20 years, and even with that real demand was not being met?" he questioned. If a higher level of energy demand was to be met, he believed that a greater role should be played by the private sector. But then it would need the incentives to invest and to attract foreign partners. "If the government sets the right framework, the energy supply expansion required for a much higher growth in national income can be achieved. It does, however, require a stable economic and political environment, with a government that does not keep changing the goal posts. In any event, it is simply beyond the government's fiscal capacity to finance this sort of expansion," he declared.

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If the private sector was to play its part, it should be encouraged to implement investments that are consistent with the Energy Conservation Scenario, with some aspects of the Alternative Energy Scenario. He argued that the increases in efficiency and better operating practices could be forthcoming if industrial leaders formed a Committee on Energy Efficiency under the auspices of the Confederation of Indian Industries. Support from the government in the form of energy audits would certainly help. He also argued that the government should provide subsidies to industries that are willing to undertake energy-efficient investments. Companies undertaking solar cooker development or adopting mini-hydro schemes to supply electricity should get subsidies, as was often the case in developed countries. "Industry in India is a responsible partner," he concluded. "With voluntary measures and government support we can achieve the efficiency targets laid out in the CEED Report and even exceed them."

The second speaker was **Mr. Reddy**, a leading light in the Engineers' Union. Reading from a prepared statement, he said that his organization was appalled at the amount of imported energy that was being planned for. Fuel imports alone were estimated for 2010 at $23.2 billion in the low-growth case and $32.4 billion in the high-growth case. This compared to the present fuel import bill of around $3.3 billion and a total import bill for all goods and services of $20.8 billion. The country must be more self-reliant. With a

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combination of the Conservation and Alternative Energy Scenarios fuel imports could be reduced to $5.9 billion in the low-growth case and $15 billion in the high-growth case. Not only would this be economically beneficial, it would also help the environment and increase jobs at home. The latter would depend on protecting the energy industries so that they could build the more efficient appliances and play their full part in increased efficiency in the electricity generation sector. Contracts for building the urban transport systems should go to Indian companies, providing jobs for Indian workers.

The third speaker was **Mr. Rawal**, an environmental activist. "India should not declare its hand by making this report public," he asserted. "My concern is that we should gain as much as we can from the climate change negotiations. Ideally, we should press for a trading permit system for CO_2 emissions, where each country has a quota based on its present population. Then India would have an allocation of 1.1 tons per person, whereas we only use 0.2 tons per person. If a global agreement was reached where a 20 percent cut in overall terms was agreed by the year 2010, we would still be entitled to emissions of 0.88 tons per person whereas we would be using anything between 0.31 and 0.59 tons per person in India in 1990, depending on which of the scenarios we take. That would leave us the opportunity to sell the balance on the open market. If we follow the Energy Conservation Scenario, we can 'sell' permits to 460 million tons of CO_2. That is equivalent to about 125 million tons of carbon. The current going rate for a ton of carbon has been estimated to be anything between $10 - $50 a ton, which would yield a revenue of between $1.25 billion and $6.3 billion a year for general development purposes. This is a chance for us to exploit our rightful share of a global natural resource. Why not take it, when the developed countries certainly would?"[1]

This is a chance for us to exploit our rightful share of a global natural resource. Why not take it, when the developed countries certainly would?

The fourth speaker was **Ms. Singh**, president of the Environmental Fund for India. She was most concerned about the environmental implications of the analysis. "The summary report only gives a part of the picture, but even that is dismal," she declared. "Even if we can achieve this reduction in SO_2 and particulates — which I doubt — we will have worse air quality than we have now. And what we have now is bad enough. People are being killed by the pollutants. Recent research shows that the concentrations in our cities are lethal. We must go for a much more radical solution, which reduces energy consumption by much more. Our research shows this can be done without jeopardizing our development. In any case, who wants development if it means such a deterioration in the quality of life? Your use of income or GDP as a measure of welfare is flawed, as we all know. GDP stands for 'Gross Domestic Pollution,' not 'Gross Domestic Product.' My proposal is that we turn the problem around on its head by declaring the environmental goals we want to achieve by 2010, and then see what actions we have to take to achieve them."

We should turn the problem around on its head by declaring the environmental goals we want to achieve by 2010, and then see what actions we have to take to achieve them.

"Are you willing to pay any price to achieve your environmental goals?" asked the next speaker, the economist, **Professor Patel**. "It seems to me that

three important things are lacking in this report. The first is any attempt to trade off the environmental against the economic. We have set ourselves the target of five percent or six percent growth, and then we have looked at different energy strategies for achieving that target. Perhaps that is politically necessary, but is it necessary for our internal analysis?

"Second, we have only looked at the environmental options in a very limited way. I agree with Ms. Singh that the increases in pollution are unacceptable, *if the pollution is distributed as it is now*. But the impacts of these increases will depend on where the increased emissions occur. We need more geographical information than has been provided, including a more detailed plan of how individual cities are going to be affected. When we do a more detailed analysis, we will discover where we have to allocate more resources to limit the environmental impacts of increased energy use. This will require us to compare the costs and benefits of different actions, and we have seen none of that so far.

"Third, I am very unhappy that this plan says nothing about **prices**. As an economist I know that prices are a very effective tool in getting individuals and enterprises to change their behavior. Why are the demand projections drawn independently of prices? We know that the costs of energy are much too low. Compared to the marginal cost of generation; average electricity charges are around 60 percent. Why not consider raising those charges, thereby reducing demand and emissions at the same time? As a nation we are not very energy efficient, although we are also small users of energy compared to the rich countries. A shift to higher energy prices would encourage efficiency, and I do not believe it would affect our overall economic performance. In fact, by allocating resources more effectively, it would result in higher growth and a better environment."

Prices are a very effective tool in changing behavior. A shift to higher energy prices would encourage efficiency and would not affect our overall economic performance.

"I agree with Professor Patel," said **Dr. Sharma**, an economist who specialized in environmental issues. "But I would go further. I would like to see a policy of making the polluter pay. Much of the thinking on environmental protection in other developing countries is moving in this direction. If we impose environmental taxes based on the emissions and the damages they do, there will be several benefits. One is that the more polluting technologies will become less attractive, especially at the more sensitive locations. The other is that the revenue raised can be devoted to supporting the shift to cleaner technologies. There are many variants on the theme of economic instruments for environmental protection. We should examine these options and make some recommendations, especially with regard to vehicle pollution in cities, thermal power generation, and emissions from heavy industries."

A policy of making the polluter pay.

"Certainly these issues need to be addressed," said **Mr. Desai**, a senior civil servant in the Ministry of Finance with a wealth of experience and knowledge about the country. "What worries me about these plans is that we have seen them before. Planners set out actions they would like to see and calculate their consequences in physical terms. What is missing is the human

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If these investments in more efficient bulbs, stoves, fridges, etc., are such a good idea economically, why are people not adopting them anyway?

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dimension. How are we going to get people to be more energy efficient? If these investments in more efficient bulbs, stoves, fridges, etc., are such a good idea economically, why are people not adopting them anyway?

"The answer, I am afraid, is that they involve capital expenditures now, with returns in the future. We are a capital constrained nation, and people do not have the savings, especially in the poorer households. They will need some support in the form of subsidies if they are to take these measures. But as a government we do not have the funds to offer that support. Perhaps we should look to external funding for these programs. The other possibility is that we get the rich to subsidize the poor. We already do this to some extent with our block tariffs for electricity, so that the rate per Kwh increases with the amount consumed. This allows the poor households to consume a small amount at an affordable cost without total revenues being affected by the subsidy. The same can be done by offering low-income households subsidies on energy-efficient items, paid for by a tax on pollution."

Professor Bhojedhur tried to sum up the discussion. "I think we all feel we have a useful initial document, but it is clearly not enough. We need more analysis before we can make any recommendations. First, we need to reconsider the demand forecasts. A more detailed comparison with other countries should be made and we should evaluate the implications of higher energy prices at home in greater detail. I am sure there will be representations by industry that this makes it uncompetitive in world markets. That has to be answered, as does their claim that voluntary measures will work.

"Second, we need to look at the Energy Conservation Scenario and the Alternative Energy Scenario more closely. The eventual policy direction has to lie with those two. The BAU scenario is too costly, has too high an import content, and is environmentally unsatisfactory. The analysis has to examine the trade-offs between environment and economy in greater detail. As a follow-on step, I suggest we ask CEED to look at two areas where there are severe environmental problems — the City of New Delhi and the coal mining area of Singrauli. Let us ask for a detailed evaluation of the options and how the Energy Conservation Scenario was put together. Although the report is quite long, it is skimpy on some details. It is a bit like one of those dosas you buy from the street-side restaurants — they taste good, but you wonder what was inside them.

"Third, I think we need to explore the policy side more closely. We should ask what financial measures will be required to achieve each of the targets that have been specified and where those funds will come from. As you know, the Ministry of Finance will not sanction anything that does not identify funding sources that cover proposed expenditures. Under this general umbrella, we should also examine the scope for environmental instruments, such as pollution taxes. The points raised by Mr. Rawal are interesting but, I believe, fanciful about the transfers India can receive from the international community. We should work on the basis of more modest external receipts, although by all means we should try and get the maximum possible.

"Finally, CEED should write a separate section dealing with the equity aspects that have been raised. How can we ensure that whatever measures are proposed do not cause extreme hardship to low-income groups and to the poor?" With these remarks the meeting went on to draft the terms of the follow-up work required.

How can we ensure that whatever measures are proposed do not cause extreme hardship to low-income groups and to the poor?

Questions for Discussion

(1) Evaluate the above discussion of the CEED report with respect to the comments you made about the report at the end of Section II.

(2) Is the summing up by Professor Bhojedhur accurate? In what areas and on what terms would you commission further research/data gathering to arrive at a final report that would make a set of politically acceptable recommendations, at the same time as addressing the economic and environmental issues raised?

IV. Follow-up Investigations

The required additional work proved to be difficult to carry out in the time available. CEED provided the following answers to the questions raised by the Task Force.

A. Energy Demand Forecasts

CEED believed that with higher prices for some of the energy sources estimated demand would be reduced, but it was unable to make any firm estimates in the time available. In terms of the gaps between supply and demand, it believed those could be eliminated with relative ease for coal, especially in the low growth case. For example, the demand for coal in the BAU was 30 MT higher than the planned output of 646 MT for the year 2010. Assuming a demand price elasticity of -0.4, which was a reasonable 'ball-park' figure for coal, it would need a price rise of only 11 percent in real terms to eliminate that deficit. It was much more difficult to make an assessment for oil, as around 40 percent of the nation's needs would be imported by 2010. The implications of higher oil prices would need further analysis, including the implications for growth and competitiveness. However, CEED pointed out that—based on work carried out by the Asian Development Bank—there was no clear link between energy prices and economic performance in a cross-section of Asian countries examined between 1960 and 1990.

Work carried out by the Asian Development Bank suggested that there was no clear link between energy prices and economic performance.

B. Closer Examination of the Energy Conservation and Alternative Energy Scenarios

CEED referred to the detailed documentation for more information on the technical aspects of these two scenarios. It also provided detailed plans for the two areas of Singrauli and New Delhi.

Singrauli is a region in Central India, bordering Madhya and Uttar Pradesh states, with one of India's largest coal reserves. It has been exploited using open cast mining techniques and feeds super-thermal power generation stations located around the vast Rihand Reservoir. In 1990 the area produced 25 MT of coal and had a power generating capacity of 6,760 MW. The area suffers from serious environmental degradation, with extremely high concentrations of dust, SO_2, and NO_x. The reservoir is polluted with flyash and mining sediments, and the groundwater has been contaminated with high concentrations of iron and chlorides. It is predicted that the area's population will double between 1991 and 2001. In the BAU scenario, capacity in Singrauli would have to increase to 18,500 MW by 2010. This would necessitate the limited use of flue gas desulfurization equipment to keep sulfur oxides under control. With the Energy Conservation Scenario, only 13,290 MW would be needed and treatment of coal is assumed to consist of only coal washing. CEED calculated the costs of air pollution 'damages' in terms of the costs of treatment that would be incurred. Other environmental damages were calculated in terms of the costs of lost value for forests and reclamation costs for other land.[2] CEED concluded that the difference in environmental costs between the two scenarios was not that great — $149 million in the case of the Alternative Energy Scenario and $138 million in the case of the Energy Conservation Scenario.

Delhi's environmental problems have already been discussed. Apart from its vehicle population of 1.7 million, it has four thermal power stations with a combined generating capacity of 1,320 MW. The topography and wind speed and direction do not favor the burning of fossil fuels, with pollutants getting trapped above the city. With the BAU, all air pollution would increase markedly over the planning period, with transport becoming the major polluter. If the proposed measures for energy conservation — including the building of a mass rapid transport system — are put in place, emissions in the city would compare with the present and BAU levels as given in Table 5.

Thus, air quality is barely improved for nitrous oxides, is considerably improved for sulfur oxides, and deteriorates for total suspended particulates. The additional measures under the BAU alternative include retrofitting flue gas desulfurization (FGD) and installing FGD at new plants, in addition to coal washing. With energy conservation, only new plants are fitted with FGD units and coal washing is increased. CEED acknowledges that something would have to be done about TSP levels by imposing environmental regulations on industry.

The estimates of 'damages' in monetary terms were prepared in the same way as for Singrauli, except that only air pollution costs were assessed. They were calculated in terms of the costs of removing the pollutants that were proposed for removal. On this basis the environmental costs of the BAU scenario came out at $20 million and that of the Energy Conservation Scenario at $5 million.

Table 5
Data on Air Pollution in New Delhi with Different Policies

	1990 Levels	2010 with BAU	2010 w/ Energy Conservation
NO_x	133,000	196,000	131,938
SO_2	50,000	76,400	35,500
TSP	154,000	173,000	168,700

C. Use of Economic Instruments

CEED did not feel it was qualified to comment on the use of economic instruments to protect the environment. It believed that the use of some pollution taxes might be justified based on the sulfur content of fuels, and enterprises generating TSP, NO_x, and other pollutants could pay into a fund according to the level of their emissions. These funds could then be used partly to support the introduction of cleaner technology and partly to educate people about energy efficiency. The whole issue needed further investigation. CEED did not feel, however, that India should impose a carbon tax on the carbon content of a fuel, as was being proposed in some developed countries.

The government should seek external assistance to support measures to reduce carbon dioxide emissions. The case to be made was that certain measures, which would not otherwise be taken on national grounds, could be made attractive if there was some grant financing available. Obviously, investment in some renewable energy sources was one area. Another was the adoption of more energy-efficient equipment. A credit institution that made soft loans for such equipment might be one possibility. Existing facilities of this kind existed in India and they could be expanded greatly with outside capitalization. Other instruments, such as pollution permits, product charges, etc., would need further investigation.

The use of some pollution taxes might be justified based on the sulfur content of fuels, but a tax on the carbon content of a fuel should not be imposed.

D. Equity Aspects

CEED acknowledged that it had not addressed the equity aspects adequately and pointed out that this would need further work. The adoption of newer, energy-efficient equipment would indeed place a capital burden on low-income families. This could be addressed through the channels described above, and Mr. Desai's suggestion was a good one. But working out the details would take a long time. Perhaps this should be done by the government itself.

Questions for Discussion

(1) Do you think that CEED's response on prices and energy demand is sufficient? In what ways would you like to see this issue addressed?

(2) Evaluate the methods used in preparing the detailed proposals for Singrauli and New Delhi, paying special attention to the additional measures and how they were evaluated. In particular, how useful is the role of the damage estimates? In what ways would you like to see this analysis extended?

(3) What is your opinion of the use of special economic instruments such as pollution taxes in this context? What further information would you seek, and what recommendations would you make in this area?

(4) What are the main questions we need to ask about the equity aspect and how would you answer those questions?

(5) How would you advise the government to handle the international negotiations on the climate change question?

V. Conclusions

The members of the task force felt that they had gained some further information, but it was still less than they would have liked. On energy pricing, they felt that the question was beyond their control. There were so many political forces that influenced energy prices that they did not feel they could make firm recommendations on the question. However, they would recommend that energy prices were one important route by which conservation could be achieved, and perhaps the only one that had proven itself. If higher environmental standards were instituted, prices would rise anyway, thus reducing demand. If pollution taxes were used, that would have a similar effect.

The detailed plans for the selected areas were not satisfactory. Probably more needed to be done to improve the environment, but the study gave no idea of what the costs and benefits of further improvements were or whether the measures proposed were, in fact, the least-cost measures. The estimates of environmental damages were of no help in this regard, as they were based on the costs of the abatement measures.

The Task Force decided to recommend a further study on the desirability of pollution taxes and on their impacts on employment and international trade, in addition to the environment. There was no general agreement on how desirable they were. There *was* general agreement, however, that India did not want to end up in a situation where the authorities had to ration the use of cars or emissions from industry simply because the environmental impacts were getting to be unacceptable. This was the present situation in Mexico City, and New Delhi was not far from similar levels of certain pollutants (perhaps 10 - 15 years).

Everyone felt that it was a very good idea to get the polluters to pay into a fund from which changes necessary for a cleaner energy policy were funded. This fund could be supported by external sources and could make a big difference.

India did not want to end up in a situation where the authorities had to ration the use of cars or emissions from industry simply because the environmental impacts were getting to be unacceptable.

Final Question for Discussion

The whole group should review the entire case study, focusing this time on how the use of **environmental economics** could help to resolve the issues and problems that have arisen in this case study. Pay particular attention to the analysis of valuation and regulation that have been developed in this seminar and see how they can be adapted to this application.

Appendix: "Wheels of Progress"[3]

For hapless residents of already overpolluted cities, there is bad news: the country is poised for a massive boom in vehicles on the road and their exhausts will prove a major health hazard. India should be producing 2,000,000 cars a year by the end of this decade. Permission has already been granted for the manufacture of 3.5 million two-wheelers also by 1990. A direct consequence of this surge in the number of vehicles will be a sharp rise in air pollution.

Delhi is a pointer to the future. According to Professor J.M. Dave, dean of the School of Environmental Sciences at Jawaharlal Nehru University (JNU), it is the worst polluted city in the country as far as vehicle exhausts are concerned. Dave and his team of researchers conducted a comprehensive air pollution survey and found that 400 tonnes of pollutants are vomited every day by nearly 5,000,000 vehicles. This amounts to 34 percent of the smoke and dust emitted in the city, a higher proportion that anywhere else. What is more, over the past decade the pollution in Delhi has increased 75 percent.

It is interesting to note pollution generated by different types of vehicles. Heavy vehicles — trucks and buses, mostly diesel — constitute only 8 percent of the total number but consume 70 percent of petroleum products and produce 47 percent of pollutants. Two-wheelers and three-wheelers constitute 63 percent of the number, consume 9 percent of petroleum products and produce 13 percent of the total pollution. However, scooters and motorcycles emit twice as much hydrocarbons as cars and the same as heavy vehicles. In other words, they contribute 29 percent of all the hydrocarbons — eight times more, per unit of fuel consumed, than heavy vehicles. Two- and three-wheelers are real culprits which explains why, despite so many more cars in Bombay, it isn't so badly off in this respect.

Vehicle exhausts are concentrated at arterial roads and junctions. The JNU researchers found carbon monoxide levels as high as 100 parts per million (ppm) over a few minutes and 5 ppm to 8 ppm on an eight-hour basis. Carbon monoxide is very toxic even in small doses and can damage brain tissue. Nitrogen oxides and hydrocarbons damage vegetation in addition to human health. Fumes from badly maintained internal combustion diesel engines can cause cancer.

A lethal contaminant in the atmosphere is lead — no less that 400 kg are released in Delhi every day. Traffic police and road construction workers are particularly vulnerable to it. Samples from leaves on certain roads show a lead concentration of up to 5 ppm. Lead is an accumulative nerve toxin, which can cause irreversible damage like mental retardation and other extremely debilitating, but hard to measure, affects. Children absorb it five times faster than adults.

Sulphur dioxide is yet another major irritant. It triggers off a number of diseases in the respiratory system including bronchitis, asthma and breathlessness. Bombay is particularly afflicted by sulphur dioxide pollution because of the dense traffic — half the taxis and a fifth of the private vehicles in the country.

Noise is a much neglected pollutant. Two- and three-wheelers — particularly motor bikes with 'rigged' silencers — roar around at a decibel level of 92 at 40 km per hour. Similarly, heavy vehicles which have faulty transmission systems can raise 85 decibels to 97 decibels at 35 km to 50 km per hour. Residents of Daryaganj, where traffic jams are common, and the Ring road have more than their fair share of this din.

There are now an estimated 900,000 cars in the country. Very little is being done to subject them, and heavy vehicles and two- and three-wheelers, to regular roadworthiness tests. According to one survey, only 65 per cent of the buses in a major Delhi Transport Corporation (DTC) depot could pass fitness tests if they were stringently applied. The Delhi administration had issued a notification requiring vehicles over 15 years old to be re-registered — eight out of ten motor vehicles in India are over 10 years old. However, it is easy to get an unroadworthy vehicle passed by a corrupt inspector.

Oil industry sources say that the use of 87-octane petrol, which was introduced in September 1983, will lead to less pollution, contrary to the popular impression. Fortunately, lead is easy to remove from petrol. Tetraethyl lead is usually added to increase the octane rating of petrol and reduce 'knocking.' Now, other additives are available. Two percent added to the cost can apparently reduce the lead content from 0.4-0.5 grams per litre to 0.1 gram per litre; the Indian Standards Institution limit is 0.56.

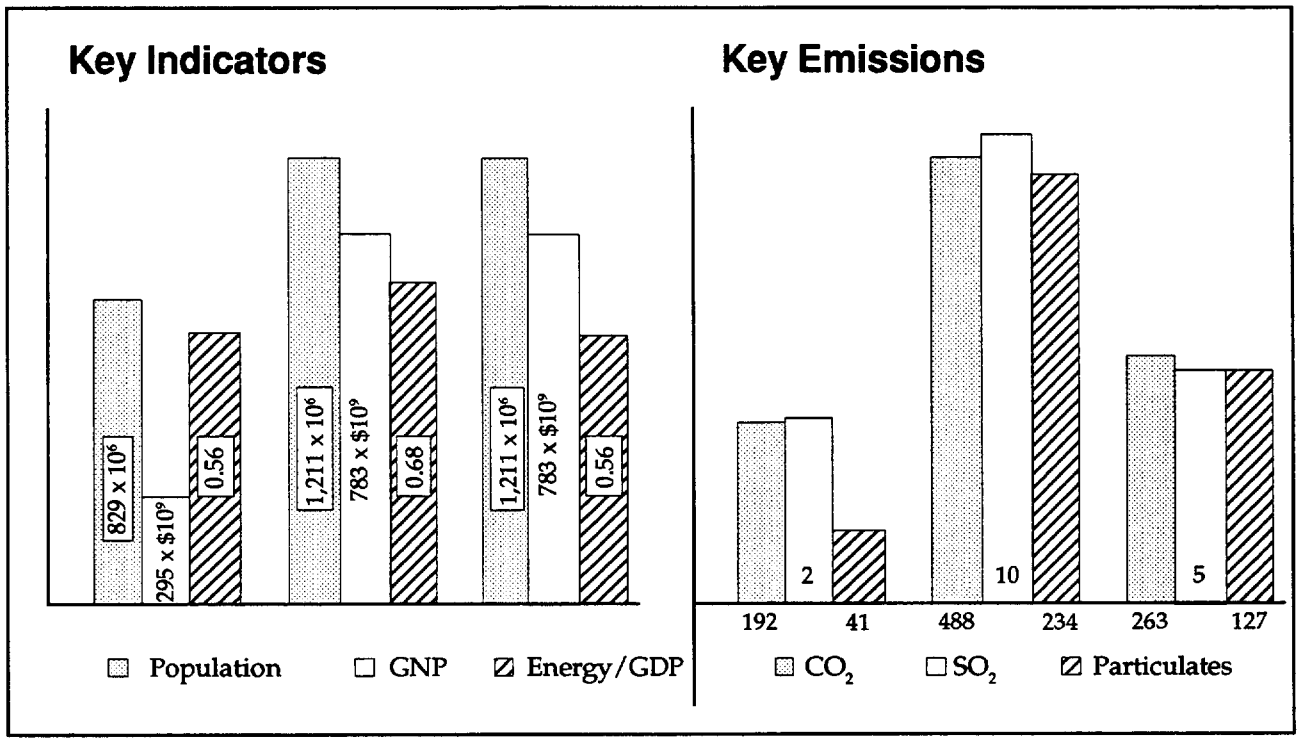
Britain has banned lead in petrol and the US and Japan offer unleaded as well as standard petrol. "We have not yet done so because it would mean remodelling the existing engines and an added expense for the consumer," says K.K. Ranganathan of the Central Board for the Prevention and Control of Water Pollution.

The board plans to monitor lead levels in Gauhati and Patna, where high lead petrol from refineries in Gauhate, Digboi, and Barauni is sold. Five refineries are producing 87-octane petrol through a process which does away with the addition of lead.

Although the Air (Prevention and Control of Pollution) Act was passed early in 1981, a great deal needs to be done. Consciousness about the careless emission of industrial fumes is certainly increasing. But unless every state government starts subjecting smoky engines to periodic inspections, there is little hope of ever cleaning up the atmosphere in major towns.

Endnotes

1 These calculations are based on the following assumptions. According to Table 4, carbon dioxide emissions rise to 263 MT in the Energy Conservation Scenario and 488 MT in the Alternative Energy Scenario. India's allocation would be 0.88 tons (20 percent less than 1.1) per person multiplied by 829 million people (the 1990 population). That gives 730 MT of carbon. Taking away what is used leaves 460 MT in the Energy Conservation Scenario and 242 MT in the Alternative Energy Scenario. This is converted into millions of carbon-tons by dividing the output by 3.67, which is the tons of carbon dioxide per ton of carbon.

2 The value of lost forest took account of timber as well as other forest products derived from the kind of forests found around Singrauli. The estimated figures were based on a detailed study carried out by T.M. Das, 'Value of a Forest,' *Indian Science Congress* (1980). The other valuations are all based on costs of mitigation.

3. Centre for Science and Environment, *The State of India's Environment, 1984-85: The Second Citizens' Report* (New Delhi: Ambassador Press, 1985), pp.131-32.