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REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

(PHASE II)

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REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

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Contents

STRATEGIES FOR LIMITING CARBON DIOXIDE EMISSIONS IN INDIA

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Executive Summary

Total energy supply in India is of the order of 400 million tonnes coal-equivalent (MTce), of which about 170 MTce is biomass-based fuels. The total carbon dioxide emissions from fossil fuels are about 92 million tonnes of carbon (MTC). Fossil fuel supply is expected to rise to about 340 MTce by 2000, implying CO_2 emissions of 136 MTC. Biomass fuel consumption is expected to rise to about 250 MTce.

The potential for reducing primary energy consumption, principally of CO_2-producing fuels, without reducing end-use services is examined in this paper. Three strategies have been investigated: increase in energy utilization efficiency (in the electricity, industrial transport, agricultural and domestic sectors); larger deployment of renewable energy technologies; and afforestation. For each strategy, the realistic potential realizable by 2000 AD has been assessed. The projected implementation of each strategy already planned has been identified. The cost of implementing the incremental potential (i.e., the cost of extending implementation beyond the planned level to the realistically realizable level by 2000) is then calculated, along with the reduction in CO_2 emissions due to incremental implementation. For each option, the specific cost of CO_2 removal is also calculated. Table S-1 lists the incremental potential, the incremental cost, and the specific CO_2 removal cost for each option.

The largest potential for reducing CO_2 emissions is through afforestation; the specific cost of emission reduction by afforestation (Rs.2,160/T carbon) is also amongst the lowest of all the options identified. The energy-related options have specific reduction costs ranging from 686/T carbon to Rs.4,34,783/T carbon. The cost curve for annual CO_2 emission reduction is generated by arranging the options in ascending order by specific reduction cost, and then adding incremental potentials to obtain cumulative reduction, and adding incremental costs to obtain cumulative cost. The resulting cost curve for energy-related options is shown in Figure S-1. The sharp gradient of the curve represents the largest quantum of reductions of the order of 40 million T of carbon per year, which are obtained by investments of about Rs.600 billion.

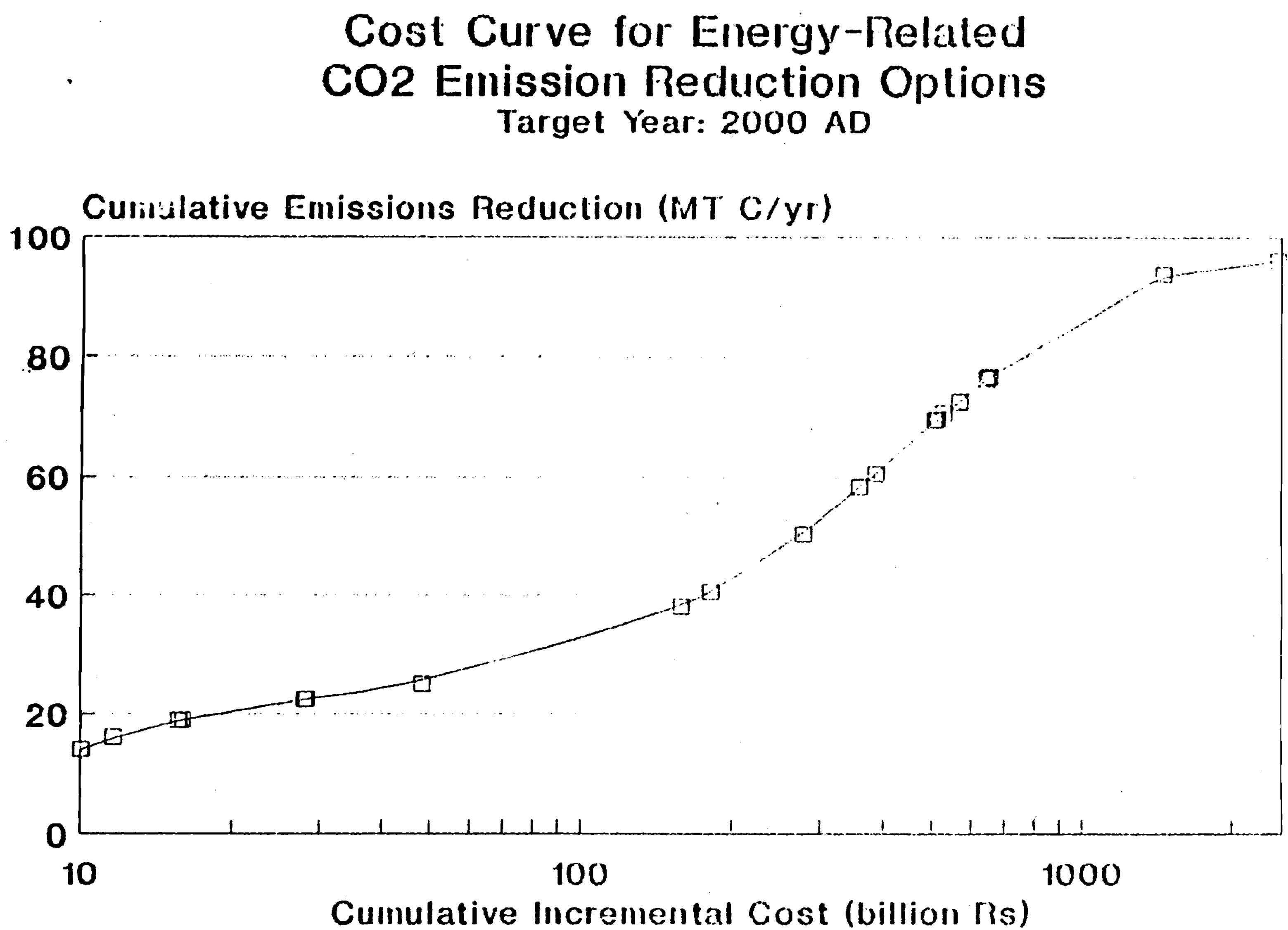
Table S-1: **Incremental potential and cost of various CO_2 emission reduction options**

	Incremental Potential for Reduction in CO_2 Emissions (MT of Carbon)	Incremental Cost (Billion, Rs.)	Specific Cost of CO_2 Reduction (Rs./T Carbon)
1. Increase in Energy Utilization Efficiency			
1.1 <u>Electricity Sector</u>			
* Electricity Generation			
- Coal Washing	14	9.6	686
- Replacement of Coal TPS by Gas Combined Cycle TPS	2.2	28	12,727
* Transmission & Distribution			
- Reduction in T&D Losses	9	120	13,333

Contd...

Table S-1 Contd..

1.2 Industrial Sector			
* Improved Housekeeping	2.8	4	1,429
* Installation of Energy-Efficient Equipment, and Better Instrumentation & Control	3.5	12	3,428
* Upgradation of Technology	2.5	20	8,000
1.3 Transport Sector			
* Enhanced Urban Public Transport			
- Increasing Bus Fleet	0.7	13	18,571
- Metro Rail Systems	2.3	1,000	4,34,783
* Enhanced Rail Freight Movement	4	185	47,059
1.4 Agricultural Sector			
* Pumpset Rectification	10	95.7	9,570
1.5 Domestic Sector			
* Improved Firewood Chulha	2	2	1,000
* Improved Lighting			
- Replacement by Tube Fluorescent	2.5	22.5	9,000
- Replacement by Compact Fluorescent	13	110	8,462
2. Deployment of Renewable Energy Technologies			
2.1 Low-Medium Temperature Solar Devices			
* Solar Cookers			
- Family Size	0.12	0.3	2,500
- Community	0.02	0.07	3,500
* Solar Hot Water System			
- Domestic	0.01	0.34	34,000
- Industrial	0.07	1.22	17,429
* Solar Timber Kiln	0.01	0.11	10,900
* Solar Au Heaters/Dryers	0.02	0.09	4,400
2.2 High Solar Power Generation			
* Line Focussing Steam Cycle Power Plant	0.18	2.99	1,661
2.3 Electricity from Other Renewables			
* Biomass	7.8	80	10,256
* Wind	3.7	75	20,270
* Small Hydro	2.0	40	20,000
* Sewage Sludge	0.08	1.25	15,625
* Distillery Effluent	0.22	4.90	22,720
* Municipal Solid Waste	0.25	5.33	21,320
* PV Pumps	0.01	1.56	1,56,000
* Windpumps	0.05	0.91	18,200
3. Afforestation	35	210	600



Each symbol represents the complete exploitation of an emission reduction option

Figure S-1

This paper aims at providing the elements of strategies for the limitation of carbon dioxide emissions from India. The working principle is to identify the broad strategies; the extent to which these strategies can be realistically adopted; an analysis of the constraints to their implementation; identification of incremental inputs that would be required for their implementation to the realistic level and of the institutional mechanisms that would be most suitable for channelling these incremental inputs; and the reduction in carbon dioxide emissions that would occur with the implementation of the strategies as compared to the no-strategy scenario. For all quantification, a time horizon of 2000 has been adopted.

Three broad strategies are identified here: increase in energy utilization efficiency; deployment of renewable energy technologies; and afforestation. The requirements and impacts of each of these strategies are discussed in the following in the perspective of the working principle outlined above. This paper is an analysis of strategies: both energy savings and consequent carbon dioxide emissions, as well as investments required are quantified only to a first approximation. A detailed study of each strategy would required to obtain precise numbers.

Increase in Energy Utilization Efficiency

The total "useful" energy consumption in India today, i.e., the amount of energy which is ultimately available for the doing desired work, is about 70 million tonnes coal-equivalent (MTce), whereas the total energy supply is in excess of 400 MTce[1]. The overall thermal energy efficiency

[1] P V Sridharan and A Mathur, Sustainable Management of Coal Resources in India, TERI, New Delhi, 1990.

the economy is, therefore, only 17.5%. In part, this low efficiency is because of the large amount of biomass supply (approximately 170 MTce) which is utilized at an efficiency of about 8%[2]. However, biomass fuels apart, even commercial energy utilization efficiency is less than 25%. There is ample scope, therefore, for substantial increases in energy efficiency.

The Inter-Ministerial Working Group on Energy Conservation setup in 1981 estimated that an economy-wide saving of 25% in commercial energy consumption seemed possible[3]. Appendix I lists a summary of the measures suggested by them, the savings expected, and the investments required. Twenty five percent savings in the industrial sector, 20% in the transport sector, and 30% in the agricultural sector were projected with a total investment of Rs.5140 crores (at 1982 prices).

This section re-examines the potential for energy conservation in the Indian economy, and evaluates the incremental resource requirements to implement these conservation measures.

Electricity Sector

Electricity Generation : The installed electricity generation capacity at the end of 1989-90 was 62,534 MW and the total generation during the year was about 233 TWh. Approximately

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[2] Towards a Perspective on Energy Demand and Supply in India in 2004/05, Advisory Board on Energy, Government of India, New Delhi, 1985.

[3] Report on Utilization and Conservation of Energy, Inter-Ministerial Working Group on Energy Conservation, Government of India, New Delhi, 1983.

67% of the installed capacity is thermal which contributes over 70% of the total electricity generated[4]. The efficiency of coal conversion in Indian thermal power stations (TPS) is low: the average gross conversion efficiency is 28%, and the average net efficiency is about 25%[5]. Figure 1.1-1 shows the gross efficiency - installed capacity profile. More than 70% of the TPS installed capacity operates at efficiencies below 30%, and 25% of capacity operates at efficiencies even below 25%. The present design gross efficiency is about 32%, and the system-wide design average would probably be 31%. Currently, worldwide, design efficiencies are similar (about 35%), but operating efficiencies are close to the design values. Enhancing TPS performance so that the operating efficiency approaches the design efficiency would increase their power output (at the same coal input rate) by nearly 15%: implying that CO_2 emissions per kWh generated would decrease by nearly 12%.

Some of the power generated in a TPS is utilized to run plant auxiliaries, such as coal grinding mills, air blowers, ESP, etc., and some power is lost in transformation (to transmission voltage), switching, etc. Presently, at the national average, about 10% of the power generated in a TPS is used internally[5]. Consequently, the net conversion efficiency is 90% of the gross conversion efficiency. Decrease in in-plant consumption would, therefore, also result in a reduction in specific CO_2 emission (kg carbon emitted per kWh delivered at TPS busbar).

[4] TERI Energy Data Directory and Yearbook, 1989, Tata Energy Research Institute, New Delhi, 1990.

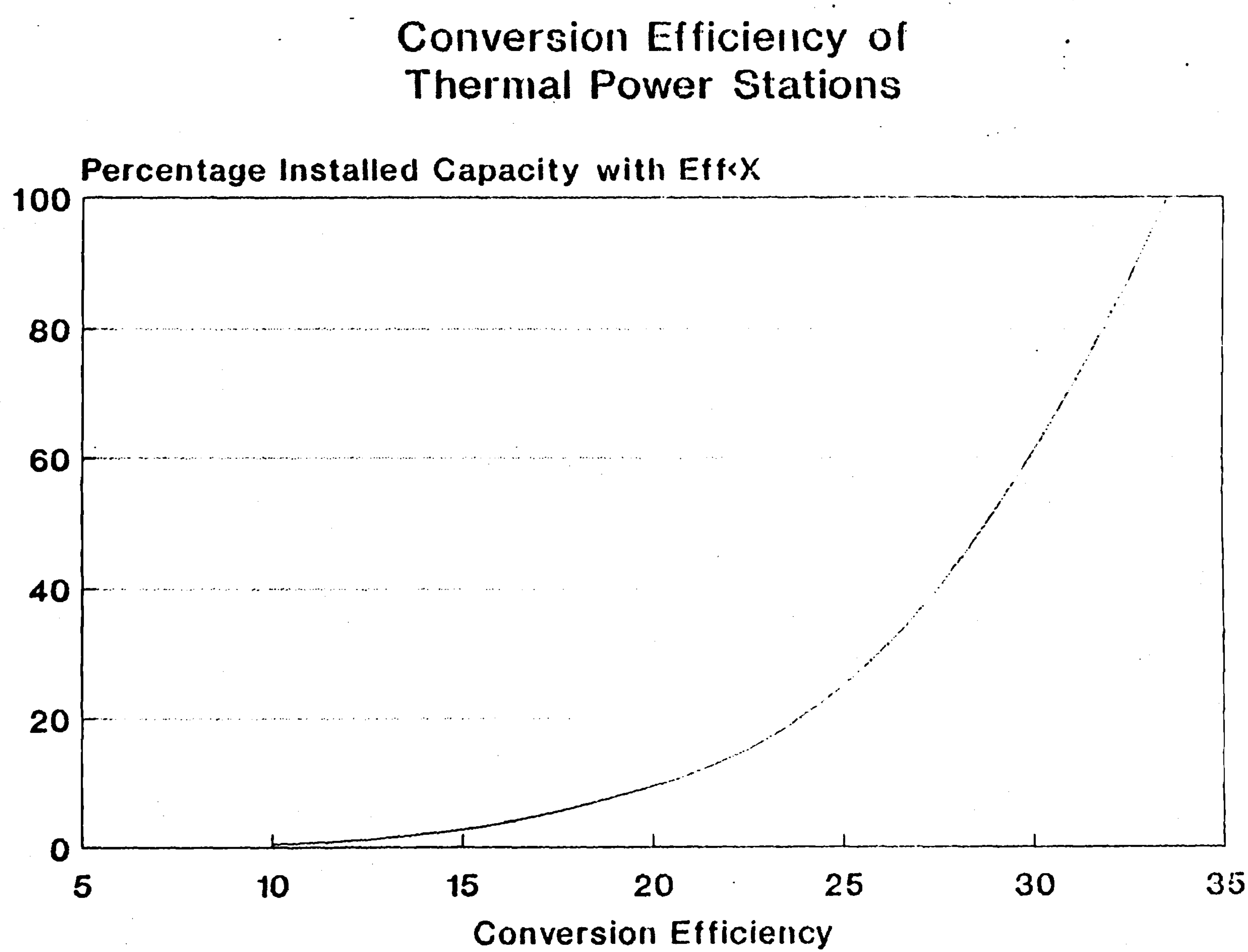

Conversion Efficiency of
Thermal Power Stations
Percentage Installed Capacity with Eff<X
100
80
60
40
20
0
5
10
15
20
25
30
35
Conversion Efficiency

Figure 1.1-1

The principal cause for low TPS efficiency is poor coal quality & poor maintenance & upkeep. High-ash coal, by itself, does not lower efficiency (in fact, boilers burning high-ash coals have the same design efficiency as those burning low-ash coals). However, coal supplied to TPS is largely from open-cast mines and has a lot of non-coal material (principally shale and rock) mixed with it. This results in poor combustion, as well as in high power requirement for grinding. Washing coal before it is supplied to TPS would greatly reduce the non-coal matter that travels with it. Boiler efficiency with washed coal rises to about 89.5%[6], and in-house electricity consumption reduces from 10 to 8% of gross generation[7].

Considering that the average TPS boiler efficiency is about 77%[8] and average in-house electricity consumption is 10%, washing coal alone would increase net efficiency by 18.8%, i.e., net efficiency would increase from the current 25% to a value of 29.5%. The specific CO_2 emission would fall from 0.29 kgC/kWh to 0.24 kgC/kWh.

There are no washeries for non-coking (power grade) coal in India. The principal reason for their absence in the

[5] Public Electricity Supply, All India Statistics, General Review 1986-1987, Central Electricity Authority, Government of India, New Delhi, 1990.

[6] Report on Trial of Benefication of Non-Coking Coal from Nandan Washery at Satpura Thermal Power Station, National Productivity Council, Calcutta.

[7] Report on the Committee to Evaluate Benefication of Non-Coking Coal for Thermal Power Stations, Planning Commission, Government of India, New Delhi, 1988.

[8] Based on boiler efficiency test carried out by the Central Electricity Authority.

lack of capital to set them up. A washery for a 1040 MW TPS costs Rs.320 million at present prices (Rs.260 million at 1987 prices)[7]. The total potential for efficiency upgradation (by 18.8%) is judged to be 45% of the total TPS installed capacity, i.e. the percentage of capacity with gross conversion efficiency between 20 and 30% (see Figure 1.1-1). This works out to a total capacity of 18,850 MW. In addition, washeries for future TPS coal supplies would also be required. Official demand projections for future capacity requirements are high, but we think that total coal-based electricity generation capacity would be about 70,000 MW in the year 2000. This implies capacity addition of about 28,000 MW between 1990 and 2000. We judge that the washed coal would continue to be 45% of total coal supplies to TPS; consequently washeries for supplying coal to 31,500 MW of TPS would be required. This implies a capital requirement of Rs. 9,600 million tonnes. The annual CO_2 emissions due to coal combustion in TPS would decrease from 94 million tonnes carbon to 80 million tonnes carbon.

Substitution of coal by gas to the extent possible would also reduce CO_2 emissions. Current plans for gas-based TPS call for an addition of 77,745 MW during 1990-95. Additions during 1995-2000 would probably be about 10,000 MW. Apart from these plans, all the gas presently flared off the West coast could be utilized for power generation in West India which would release an equivalent amount of coal. Currently, over 2.5 billion cu.m of natural gas are flared in the Bombay High basin annually[4]. This gas could generate about 12 TWh of electricity which implies an installed capacity of about 2200 MW of gas-based combined cycle TPS, or an equivalent 2,500 MW coal-based TPs using 8.5 MT of coal per year. The installation of 2,200 MW of gas-based combined-cycle capacity would cost Rs.28,000 million, and would result in CO_2 emissions reduction of 2.2 million tonnes of carbon annually.

Transmission and Distribution

Transmission and distribution (T&D) losses in the Indian power system are estimated at 22%[4]. However, owing to the practice followed by some State Electricity Boards (SEBs), of diverting a certain portion of non-technical/commercial losses towards unmetered power supply to agricultural consumers, the actual T&D losses may be somewhat higher. The Committee on Power[9] recommended a somewhat realistic target of reducing T&D losses to a level of about 15% by the year 2000. Of course, little has been done in this direction so far. In fact, percent T&D losses increased until the mid-1980s and have remained fairly stable since then (see Table 1.1-1).

Table 1.1-1 : T&D losses(%)

1970-71	17.5
1976-77	19.8
1982-83	21.1
1985-86	21.7
1987-88	21.5

Source: (i) CEA, Public Electricity Supply, All India Statistics (General Review), Various Issues.
(ii) CMIE, Current Energy Scene in India, July 1989.

[9] Report of the Committee on Power, Planning Commission, Government of India, New Delhi, 1980.

In order to identify suitable strategies to reduce T&D losses, it would be necessary to know the level of T&D losses taking place at various voltage levels in the T&D system. On the basis of available information, reasonable estimates can be made, and are presented in Table 1.1-2 below.

Table 1.1-2 : Percentage Losses at Various Line Voltages

	% Losses		
	Line	Transformation	Total
EHT (66 kV and higher)	4.0	0.5	4.5
33 kV	3.0	1.0	4.0
11 kV	6.0	1.0	7.0
45 volts	5.5	2.0	7.5
Total	18.5	4.5	23.0

It is apparent from Table 1.1-2 that a major portion of the losses take place at 11 kV and lower voltage levels. These also include non-technical losses, arising from under-recording in meters (most mechanical meters tend to slow down with age), meter tampering, defective meters, and pilferage etc. Losses arising from the latter three factors may be reduced with more care in testing and replacement of meters in time, and strict enforcement of laws to ensure that meters do not get tampered and that electricity theft does not take place. Also, a coordinated programme of periodic meter-testing and recalibration needs to be introduced. It is understood that some utilities have established meter-testing laboratories, but their achievements and performance levels need to be upgraded.

We can reasonably assume that out of 23% T&D losses, technical losses amount to 15% and non-technical losses including pilferage etc. 8%. In order to arrive at "order-of-magnitude" estimates of additional T&D investment requirements to reduce losses to 19% by the end of the 8th FYP period, it can be reasonably assumed that (i) non-technical losses reduce from the present level of 8% to about 6%; and (ii) technical losses reduce from the present level of 15% to about 13%.

Total investment in T&D systems in India in India until end of 7th FYP period	= Rs 23,000 crores (1985 prices)
	= Rs 35,000 crores (1990 prices)
Tentative investment level for T&D in 8th FYP period	= Rs 20,000 crores (1990 prices)
Total investment for T&D until end of 8th FYP period	= Rs 55,000 crores

This level of investment gives technical losses of 15%, which we aim to reduce to about 13% by end of the 8th FYP period. Considering an empirical relationship between T&D losses and T&D investment, the additional investment required in T&D systems by end of 8th FYP period is:

$$\left[\left[\frac{15}{13}\right]^{\frac{1}{2}} - 1\right] * 55,000 = \text{Rs } 4,079 \text{ crores} = \text{Rs } 40,800 \text{ million (say)}$$

Further reduction of technical losses to 11% by 2000 would involve a further incremental expenditure of the order of Rs. 80,750 million over and above the expenditure to enhance the T&D system to evacuate and distribute 1,00,000 MW of power. The non-technical losses in 2000 are assumed to be 5% - the total T&D loss thereby being 16%.

It may be mentioned that this only gives the upper bound of investment requirement for reduction in technical losses -- as some losses also occur due to improper electrical connections, improper conductor sizing etc.

Incremental expenditure of nearly Rs.120 billion would be required to decrease T&D losses from 23% to 16% between 1990 and 2000. This would result in CO_2 emissions reduction from 94 million tonnes carbon to 85 million tonnes carbon in 2000 if the entire reduction in generation possible due to increased T&D efficiency is assigned to coal-based generation.

Industrial Sector

The industrial sector (manufacturing industry) in India has traditionally been the largest consumer of commercial energy in the Indian economy. In 1988-89, about 34 per cent of the total energy commercial energy available was consumed by this sector. In terms of total final consumption of commercial energy, it was approximately 51 per cent. The contribution of non-commercial energy sources, such as bagasse, rice husk and solar energy, to this sector is negligible. The energy consumption pattern is detailed below in Table 1.2-1.

Table 1.2-1: Energy Consumption Pattern in the Industrial Sector

(Mtoe)

Years	Coal	Oil	Natural Gas	Electricity	Total
1981-82	28.958	8.864	1.003	4.479	43.304
1982-83	32.434	9.292	1.51	4.471	47.707
1983-84	34.017	9.47	1.772	4.819	50.078
1984-85	33.175	10.31	2.142	5.319	50.946
1985-86	36.109	10.413	1.083	5.654	53.259
1986-87	38.49	10.521	3.165	6.035	58.211
1987-88	35.478	11.0	3.859	6.501	56.838
1988-89	39.703	10.876	4.681	7.118	62.378

The consumption of coal, oil, gas and electricity increased steadily throughout the period 1981-82/1988-89, though oil consumption did decrease marginally in the last year. The annual average rate of growth for coal, oil, gas and electricity were 4 per cent, 2.6 per cent, 21.2 per cent and 6 per cent respectively. Total energy consumption increased at a rate of 4.7 per cent on an annual average basis.

It has been estimated that the energy conservation potential that could be realized in the 8th Plan is 15 per cent and 10 per cent in the 9th plan. The Inter-Ministerial Working Group[3] had also estimated the energy conservation potential by type of fuel. It had been calculated that with only the installation of new equipment the savings from coal-based, oil-based and electric machines were in the region of 20 per cent, 20 per cent and 15 per cent. In the short-term, implementation of improved housekeeping measures, training of personnel and energy audits could save about 7.1 MTce, or 2.8 MT carbon emissions on an investment of Rs.4,000 million. The expected savings in monetary terms is

Rs.6,160 million annually. The medium term measures include the installation of waste heat recovery systems, replacement of inefficient boilers, introduction of instrumentation and control systems and adoption of better technology at a cost of Rs.12,000 million. The savings forecast were 8.9 MTCE or Rs.7,720 per annum. This implies annual CO_2 emissions reduction of 3.5 MT carbon. In the long-term introduction of new systems e.g., cogeneration systems, adoption of new energy-efficient technologies and computerization of process control operations are expected to yield a savings of Rs.5,370 million annually i.e., 6.2 MTce. Carbon emissions would reduce by 2.5 MT carbon per year. The investment required for this was estimated at Rs. 20,000 million. The adoption of these measures in the short, medium- and long-term are expected to realize the savings forecast for the 8th and 9th plans respectively.

While there are many reasons for lack of energy efficiency in Indian industry even 11 years after the second oil shock in 1979, there are a few which are important. These are lack of awareness and training, paucity of capital, inadequate incentives, high interest rates, and large customs duty on imported items. Energy conservation policies need to focus on these issues to bring about a change in attitude and a higher level of awareness among industry managers and workers.

Three areas which are vital for a successful energy management programme in any industry are: (i) management (structure); (ii) engineering and (iii) technology. Any programme or policy measure implemented would focus on these areas.

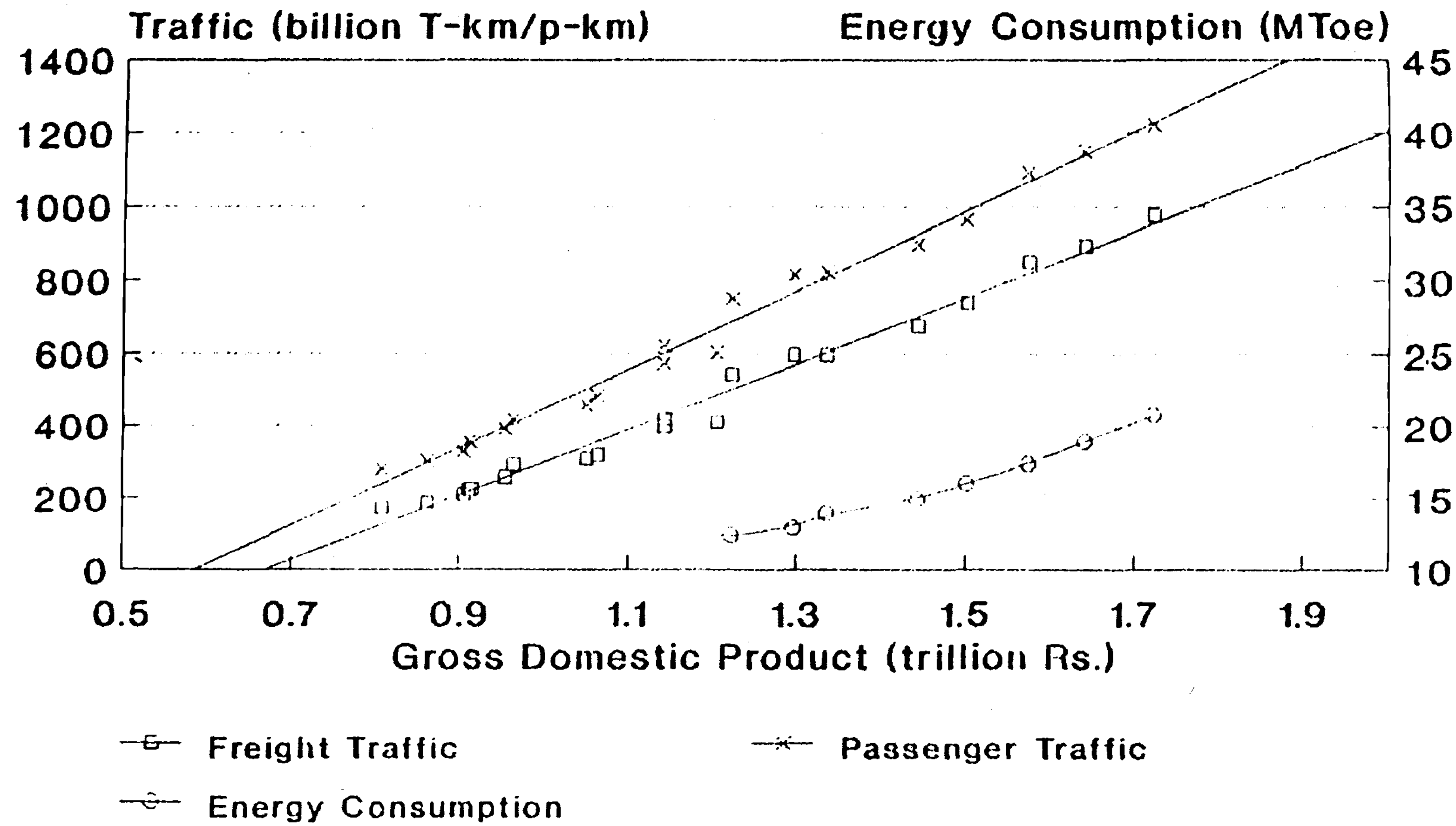
In addition to reducing the fossil fuel consumption drastically in our industry through energy conservation measures, there is a need to bring in solar thermal energy low-grade heat applications on a large scale. We should target for an incremental 5 per cent of total energy use from renewable energy sources (solar; wind and biomass) in each of the next two five-year plans.

Transport Sector

In the years since the Inter Ministerial Working Group report was submitted, the total transport requirement of the country has increased by over 40%[10]. The energy demand of the transport sector over the same period has, however, increased by nearly 70%[4]. Figure 1.3-1 illustrate these trends. The disproportionately higher rate of growth of energy consumption is primarily because of two structural shifts that are occurring in the transport sector. The first is the decreasing share of rail in both freight and passenger movement, and the second is the increased share of personalized modes of transport in passenger traffic: the share of mechanized road transport in passenger traffic increased from 67% in 1970-71 to 78% in 1987-88. In freight traffic too, the share of road transport increased from 34%

[10] Report of the Group on Perspective Planning for the Transport Sector, Planning Commission, Government of India, New Delhi, 1987.

Growth of Traffic and Energy Consumption in the Transport Sector (1969 - 1988)



GDP is at 1980-81 prices

Figure 1.3-1

to 51% over the same period. Neither of these two shifts has been addressed by the Working Group. It is, however, essential to curb these trends if the rate of energy consumption is to be at least equal to, but preferably less than the rate of growth of transport requirement.

Increased rail track kilometerage, higher efficiency and faster movement in the railways and enhanced public transport systems are two necessities for curbing the high rate of energy consumption growth.

Enhanced Public Transport System : A reliable forecast for total urban transport demand is estimated by the "Study Group on Alternative Systems of Urban Transport"[11]. According to this study, under the business-as-usual scenario, the total travel demand for 83 cities of different size and shape with population above 0.25 million is estimated for the year 2001 and is given in Table 1.3-1.

Table 1.3-1: Projections of Urban Travel Demand

Population Range (Million)	Medium Population	No. of Cities	Population (Million)	Travel Demand BPKM per year
8+	13	4	52	314.5
3 - 8	6	3	18	59.8
2 - 4	3	4	12	25.9
1 - 2	1.5	15	22.5	25.6
0.5 - 1	0.75	36	27	15.6
0.25 - 0.5	0.375	21	7.9	1.4
Total		83	124.4	442.8

[11] Report ofthe Study Group on Alternative Systems of Urban Transport, Planning Commission, Government of India, New Delhi, 1987.

Of this total projected traffic demand of 443 BPKM, it is estimated that nearly 20% of the travel demand will be met by sub-urban and urban rail traffic system. While the remaining 80% (i.e. 358 BPKM) passenger travel demand will be met by road transport by the turn of the century.

Road Transport

There has been an exponential growth in motorized vehicles - with an average growth rate of nearly 13% per annum in the last decade. The growth of two-wheelers has been very high (16.6%). The number of cars has also been growing at a higher rate (6.9%) than buses (5.7%) clearly indicating the shift from public transport to personalized transport. And it did not look particularly reassuring : if the present trend of vehicular growth continues, the disparities between supply and demand will become even more acute. To illustrate this fact, we have taken two scenarios : (1) Business-as-usual or as per present trends and (2) One possible scenario and have shown the advantage of replacing personalized transport by public transport not only in terms of energy savings but also in terms of reducing road congestion, pollution and the total cost by the turn of the century. In working out this, the following assumptions have been made:

- Total travel demand by road for the 83 cities is as in Table 1.3-1.
- As per present trends modal split for public transport will be 57% and that of cars 9%[12].

[12] Urbanization and Energy in the Third World - A Study of India, Tata Energy Research Institute, New Delhi, 1989.

- In the recommended scenario, public transport shares will be 80% and that of cars 4%.
- The balance trips to meet the total travel demand is split in the ratio 2:1 between two-wheelers and three-wheelers in both the scenarios.

Overall, the aim is to reduce work trips by personalized modes of transport (which presently constitute about two-thirds of the total trips by cars and two-wheelers) - by two-thirds. This traffic would be diverted to buses. Further bus capacity is also provided to cater to 50% of the three-wheeler traffic.

The results are summarized in Table 1.3-2.

Table 1.3-2: Implications of Suggested Recommendations

	As per present trends					As per recommendation				
	Bus	Car	2W	3W	Total	Bus	Car	2W	3W	Total
Annual Passenger Kms (10^9)	205	33	80	40	358	288	14	36	20	358
Modal Split (%)	57	9	22	12	100	80	4	10	6	100
No. of vehicles (10^3)	62	1173	7809	532	9576	87	488	3542	260	4377
PCU's (10^3)	186	1173	3904	532	5795	261	488	1771	260	2780
Fuel (10^3 TOE)	1270	1012	1277	733	4292	1786	421	579	359	3145
CO_2 Emissions (10^3 tonnes C)	813	649	818	470	2750	1145	270	370	230	2015
Cost (Rs.crores)	3379	5254	4102	2237	14972	4754	2186	1861	1096	9897

Thus, an increase in bus share from 57% to 80% leads to a saving of 11 lakh tonnes of oil. The other advantages are a 54% reduction in total vehicles on the road, a 27% reduction in carbon dioxide emissions and a 33% reduction reduction in transport costs.

The increase in the number of buses required in the recommended scenario is 25,000 buses. At today's cost this would mean an additional investment of Rs. 10,000 million. If we add 30 per cent for investments in infrastructure, Rs. 13,000 million will be required till the turn of the century to reduce CO_2 emissions by 0.735 million tonnes of carbon.

One disadvantage in the recommended scenario is that about half a million tonne of diesel fuel will be required in addition implying additional imports. This can be got over if two further measures are implemented:

- increasing the traffic carried by electrical suburban rail systems in metropolitan cities by 50 per cent more that projected by the Railways (i.e. 26 BPKM more) giving a saving of 160 thousand tonnes of diesel
- improving fuel efficiency of buses from 3.5 kmpl to 4.5 kmpl leading to a saving of 0.4 million tonnes of diesel. [This could be done partly by technological improvements in bus design and partly by traffic management measures leading to less congestion and faster flow of bus traffic.]

Rail Transport

At present, the only urban rail transport systems in India are in Bombay and Calcutta. Presently plans project that these systems would be providing a capacity of about 80 BPKM by 2000. However, urban rail transport systems lead to a reduction in energy consumption, and hence in CO_2 emissions. It is estimated that such a system in Delhi, costing Rs.25,580 million would provide a capacity of 10 BPKM annually, resulting in net savings of about 0.9 MToe[13]. Consequently, CO_2 emissions decrease by 0.57 MT of carbon.

Providing urban rail transport in Madras and Delhi, and the seven cities in Table 1.3-1 with population between 2 and 8 million so as to move 20% of the traffic (about 40 BPKM) would cost about Rs.1,000 billion, and result in CO_2 emission reduction of about 2.3 MT of carbon.

We, therefore, feel that the modal split suggested by us is feasible. An imaginative policy for bus transportation providing for different types of services, like express, deluxe etc. to cater to different interests would have to be implemented to wean away commuters from personalized transport to buses. What is needed is the will of policy makers to implement such a policy. A change in industrial policy in the automotive sector would also be needed. There will have to be an accelerated production of fuel efficient buses designed specifically for urban transport and a cut back on production of cars and two-wheelers.

Technology for the urban rail system would largely have to be imported: this includes locomotives, signalling and communication equipments, etc.

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[13] Feasibility Report of Metropolitan Railways in Delhi, RITES, New Delhi, 1989.

Increasing the Rail Line Capacity : Increased rail track kilometerage (and accompanying increase in rolling stock) is aimed at ensuring that rail transport provides the same level of service (in terms of speed and reliability) as does road transport. Figure 1.3-2 shows the relationship between freight transport demand and the GDP. The rail freight transport requirement is expected to increase to 0.37 trillion T-km by 2000, and the road tansport requirement to 0.57 trillion T-km under the business-as-usual scenario. With specific energy consumptions of 8 and 21 Toe per million T-km for the rail and road sectors, the annual energy demand for freight transport in 2000 would be about 15 million toe, and CO_2 emissions would be approximately 12 million tonnes of carbon. In order to reduce the energy consumption and CO_2 emissions by one-thirds, an additional 0.38 trillion T-km of rail capacity would have to be provided. The railways plan to create an additional capacity of 0.25 trillion T-km by 2000[14]. Assuming that completely new tracks and rolling stock are required to meet the residual demand of 0.13 trillion T-km, the total incremental investment between now and 2000 is approximately Rs.185 billion based on estimates extrapolated from the Corporate Plan of the Railways[14]. This would result in CO_2 emission reductions of 4 million tonnes of carbon.

This is completely implementable: all infrastructure to develop this additional capacity is available indigenously, or indigenous capability can be enhanced to meet this

[14] Indian Railways Corporate Plan, 1985-2000, Ministry of Railways, Government of India, New Delhi, 1987.

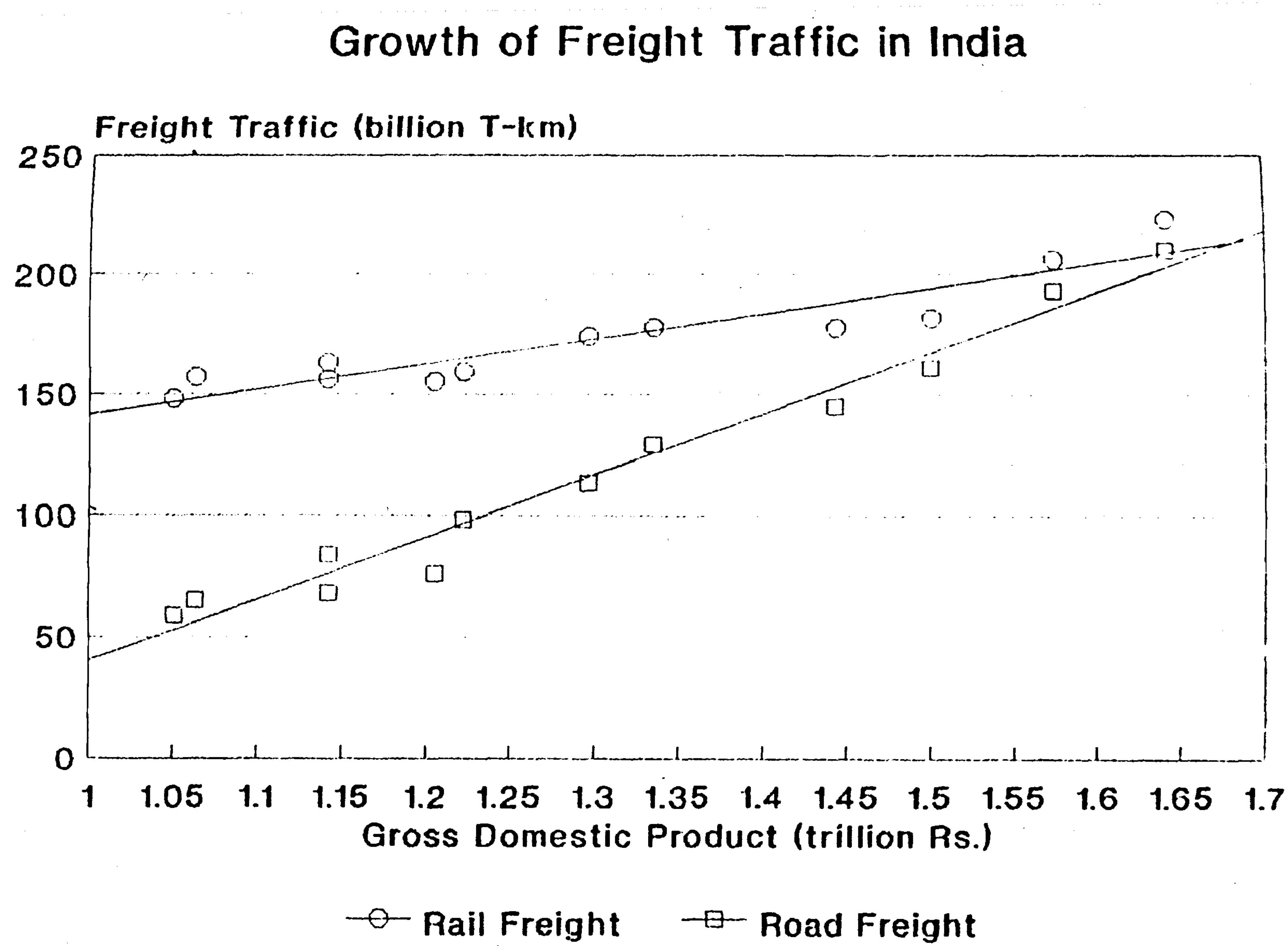

Figure 1.3-2

GDP is at 1980-81 prices

requirement. The only constraint towards the enhancement of line capacity has been, and continues to be, the lack of financial resources.

International funding for meeting the cost of this incremental addition presents a peculiar problem. The projects are economically viable, i.e., an adequate rate of return will be generated, but the income (as well as nearly all the investment) will be in local currency. Given our unfavourable balance of payments position, and the precarious situation of our foreign exchange reserves, it is doubtful whether other sectors of the economy can generate adequate foreign exchange to service this debt. Consequently, total international funding in the form of transfer of resources seems to be the only viable financing mechanism. Finally, since this entire programme would be implemented by the Ministry of Railways, the funding will have to be channeled through the Government of India.

Agricultural Sector

The problems that constrain high energy efficiency in this sector and the energy conservation measures suggested by the Inter Ministerial Working Group[3] largely hold true today as well. The major constraint in the success of these measures is the lack of financial incentives to carry them out. As long as agricultural load tariffs are subsidized, or based only on connected load, there is no incentive to the farmer to instal an energy-efficient motor, or to enhance its energy efficiency. The setting of energy-related tariffs would alone lead to a substantial decrease in electricity consumption - maybe as much as 15% - without any other inputs. On the other hand, without restructuring the tariffs, large inputs could well lead to negligible savings.

There are about 7.6 million electrical pumpsets used in the agricultural sector, which on a nationwide basis, consume approximately 38 TWh electricity every year[4]. It is estimated that complete rectification of these sets would reduce electricity consumption by about 50%[15]. The cost of rectification per set is approximately Rs.8,700 at current prices[15].

The total potential of electrical pumpsets is judged as 12 million[16], and approximately Rs.1.5 million are added in each plan period. It is therefore estimated that there will be about 11 million pumps in 2000. Rectification would cost Rs.95.7 billion, but would result in electricity savings of about 27.5 TWh per year. T&D losses for pumpset supply are 23%; consequently electricity generation of the order of 35 TWh could be avoided. This implies CO_2 emission reduction of 10 MT of carbon.

Domestic Sector

The domestic sector energy conservation potential was not addressed by the Inter-Ministerial Working Group. However, we feel that this is a particularly important sector from the perspective of energy efficiency improvements.

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[15] S.M. Patel, Low Cost and Quick-Yielding Measures for Energy Conservation in Agricultural Pumps, PAJE, 2(1), 3-11, 1988.
[16] V.P.'s Eight Five-Year Plan (1990-95): Status Paper on Power, Planning Department, Government of Uttar Pradesh, Lucknow, 1989.

Biomass Utilization : The most accurate estimates of biomass utilization in the domestic sector are based on 1978-79 NCAER survey[17]. These are summarized in the Table 1.5-1 table along with estimates of future demand.

Table 1.5-1: Demand for Traditional Biofuels in 2004/05 (million tonnes)

Source	Population (million)	Fuelwood	Dungcake	Agricultural Waste
NCAER+,[17]	641	95.5 (79.3)	71.7 (66.7)	30.6 (29.5)
WGEP[18]	-	61.3	33.6	18.9
ABE[2]	1046	312.0	207.0	94.0
EDSG[19]	1040	258.9 (187.0)	150.5 (132.2)	77.0 (71.8)
TEESE*,[20]		63.4	82.2	42.9
NCAo,[21]	-	150	-	-

Note: The numbers in brackets indicate estimates of rural energy demand.

+ These were consumption levels in 1978-79.
* The estimates are for the year 2005.
o The estimates are for the year 2000.

[17] I. Natarajan, Domestic Fuel Survey with Special Reference to Kerosene, Vols. 1 and 2, National Council of Applied Economic Research, New Delhi, 1985.

[18] Report of Working Group on Energy Policy, Planning Commission, Government of India, New Delhi, 1979.

[19] Report of Energy Demand Steering Group, Planning Commission, Government of India, 1986.

[20] Development of a Quantitative Model for Systems Evaluation of Energy Related Technologies (TEESE Model), Tata Energy Research Institute, New Delhi, 1988.

[21] Central Forestry Commission, India's Forests, Forest Research Institute and Colleges, Dehradun, 1985.

Assumptions Made in Various Studies

WGEP[18]

a) Total household energy consumption norm is fixed at 0.4 tcr per capita per annum in urban areas 0.38 tcr per capita per annum in rural areas

b) The use of commercial energy sources will increase to such an extent that the consumption of the non-commercial fuel for cooking will be reduced to about 70 per cent of households in the rural areas and 10.8 per cent households in urban areas in the year 2000.

c) The allocation of non-commercial fuels among fuelwood, agricultural residues and dungcake is assumed in the ratio of 65:20:15.

ABE[2]

a) Total household energy consumption norm is fixed at 650 kcal per capita per day.

b) NCAER 1978/79 pattern of fuel consumption will be valid for 2004/05 also.

EDSG[19]

a) The average useful heat consumption
= 650 kcal per capita per day for urban population
= 520 kcal per capita per day for rural population

b) Stove efficiency is 8 per cent.

c) NCAER pattern of fuel consumption will be valid for 2004/05.

TEESE

a) Fuelwood demand is fixed at the level of its consumption estimated for 1984-85.

b) Dungcakes availability is determined within the model as a function of the optimal number of draught cattle and a fixed number of milch cattle.

In the context of strategies for limiting CO_2 emissions from India, strategies to reduce demand for woody biomass play an important role. In this context the role of the programmes to promote biomass stoves becomes significant.

The current National Programme on Improved Chulhas (NPIC) has a target of 1.827 million stoves for 1990-91 at a financial outlay of Rs.125 million. It is estimated that by the end of the year 1989-90, there will be about 8 million improved cooking stoves on the ground. It is estimated that approximately 65% of installed improved chulhas are used, and that these result in a 25% reduction in wood consumed; about 0.23 tonnes wood annually[22] for each chulha. An outlay of Rs.125 million, therefore results in the saving of 0.270 MT of wood annually, or a reduction in CO_2 emissions of 0.12 MT of carbon.

Considering that there are about 80 million traditional biomass stoves in the country, and that annual targets are of the order of 2 million chulhas, about 30 million chulhas would be in place by 2000. Additional resources of the order of Rs.2000 million would place another 30 million chulhas in place, and reduce CO_2 emissions by 2 MT of carbon every year.

[22] V Joshi, Rural Energy Demand and Role of Improved Chulha, in <u>Energy Policy Issues</u>, Volume 4(1988), Tata Energy Research Institute, New Delhi, 1989.

It is obvious that this strategy alone is not adequate to limit and improve the role of biomass fuels in cooking.

A more comprehensive enduse based planning approach using following strategies in the domestic sector may contribute to varying degree towards limiting CO_2 towards emissions from India.

1) More rapid and effective promotion of biomass based improved cooking stoves and biogas plants.
2) In the long term biofuels should be processed to obtain better quality fuels to be used with higher efficiency.
3) Implementation of area based cooking energy plans to substitute biomass with better quality fuels. For example,
   - o Excess hydro-power in the hills,
   - o Piped NG near the north-east and other NG rich areas,
   - o Coal briquettes or coal gas mixture in the coal belt,
   - o Sewage gas in urban areas.

Lighting : The current stock of electric lamps in India is about 600 million: 400 million incandescents and 200 fluorescents. Incandescent lamps convert about 4% of the input electricity into light, whereas the conversion in fluorescents is about 10%. Compact fluorescents are currently not manufactured in India, and cost about Rs.250. Their life is in excess of 8 years; tube fluorescents have a rating of 50 W, last 4 years, and cost Rs.125; incandescents cost about Rs.50 to install, last about an year, and have an average rating of about 80W.

It is projected, current trends continuing, that the installed lamp stock in India would be about a billion in 2000: 600 million incandescents and 400 million fluorescents. Approximately 50% of the 80W incandescents are judged to be replaceable by 50W fluorescents. The incremental cost of this conversion would be about Rs.22.5 billion, but the annual energy savings would be 9 TWh. Assuming T&D losses of 23%, and coal-based generation to account for 70% of total generation, the reduction in energy requirement would be about 8.2 TWh annually. This implies CO_2 emission reduction of 2.5 million tonnes of carbon.

Alternately, if all tube fluorescents and 50% incandescents are replaced by compact fluorescents, the cost would be Rs.110 billion, but energy savings would be 43 TWh, or 39 TWh of coal-based electricity. This implies CO_2 reduction of 13 MT of carbon.

Deployment of Renewable Energy Technologies

In the future, with the growth in the demand for energy, judicious resource use will have to be the cornerstone of a sustainable development effort, in which renewable energy sources can, and will, play an important role. Even at the present costs there are many applications in which some renewable energy technologies are cost effective in addition to being environmentally benign.

In the power sector, for example, windfarm power generation competes favorably with the cost of coal thermal route to electrical power generation. In the past five years, the Department of Non-conventional Energy Sources (DNES) has commissioned a total of 10.1 MW of windturbines which have fed over 22 million kWh of electricity to the central grid at costs averaging in the range of Rs. 1 to Rs. 1.5 per kWh. The estimated costs in the future are expected to be as low as Rs. 0.80 per kWh and the DNES proposes to add as much as 5,000 MW of wind-power generating capacity by 2000 A.D. A study by the Tata Energy Research Institute[23] estimates the potential of windfarms in India at about 16,000 MW while DNES places this figure at 20,000 MW. In reality the ultimate potential for harnessing wind for power generation is much higher (according to the TERI study, the ultimate potential exceeds 200,000 MW and is limited by the maximum possible penetration in the existing grid) and would depend on the development of low cost energy storage systems in order to increase the penetration.

There is, similarly, a large potential for solar energy applications. Though soalr energy applications are likely to be more cost effective in the medium temperature (100-150°C) range, there are a whole range of applications which are and are likely to be cost effective in the comming decade. These can have a significant effect on the reduction of fossil fuel consumption.

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[23] J Hossain, An Assessment of Potential for Installation of Windfarms in India, Paper presented at the PACER Conference on Role of Innovative Technologies and Approaches for India's Power Sector, Organized by TERI and PFC, Delhi, April 1990.

For example, the savings from the targeted low and medium temperature solar thermal devices recommended for the Eighth Plan period (DNES, 1988) based on the possible displacement of alternate fuels is given in Table 2-1 below. The proposed 0.46 million family solar cookers would displace an estimated 276,000 tonnes of fuelwood per year while the community solar cookers could substitute about 50,000 tonnes of fuelwood annually if deployed solely in rural areas or reduce consumption of fossil fuel based energy sources in urban areas. The benefits/savings from domestic hot water systems, based on the quantity of electricity displaced, is estimated at 41.7 MkWh per year, while for industrial hot water systems and solar air heaters the estimate is based on fuel oil savings. The estimated savings total about Rs.4800 million annually while the one time investment amounts to Rs.2,125 million. It should be noted that the savings accrued from the solar technologies (especially for industrial applications) are through the savings in commercial, and largely fossil, fuels and thus there are possibilities of considerable reduction of consumption in these sectors.

Table 2-1: Savings from Solar Thermal Devices

	Number	Cost (Million, Rs.)	Savings (Million-Tonnes Carbon)
1. Solar - low and medium temperature			
(a) Solar cooker			
(i) family size	460000	296.6	0.12
(ii) community	21500	67.6	0.2
(iii) concentrating models	500	3.0	0.02
(b) Hot water systems			
(i) Domestic	46000	341.4	0.01
(ii) Industrial	460000 sq.	1220.0	0.07
(c) Solar timber kiln	0.11 m.cu. (775 in #)	109.0	0.01
(d) Solar air heaters/dryers	50000 sq.m (100 in #)	88.0	0.02
TOTAL		2125.6	0.45

In Table 2-2, the proposed plans of the Sub-group on Solar Thermal Technologies (for the Eighth Plan) for power generation through the use of solar energy is summarized. Though there are no operational line focusing, steam cycle power plants in the MW range, the Sub-group felt that the target of 8 plants of 30 MW installed capacity each was achievable in the Eighth Plan period. The estimated costs of the recommended projects are listed below in Table 2-2. The annual CO_2 emissions from coal-based TPS generating equivalent energy are also listed in Table 2-2.

Table 2-2: Solar Thermal Power Generation Proposal: Summary

Solar- high temperature	Number/ apacity	Total cost (million, Rs.)	Cost/KW (Rs./KW)	CO_2 Emission Reduction (MT of Carbon)
(a) Line focusing-steam cycle power plant	8 (8x30MW)	2987	41458	0.18
(b) Dish-Stirling power plant	11 (148KW)	20.8	269595	Negligible
(c) Solar pond power plant	2 (650KW)	28.0	43077	Negligible
TOTAL		303.58		

Based on the potential for other renewable energy sources, our estimates of DNES projections for the achievable targets are listed in Table 2-3 below, alongwith CO_2 emissions from coal-based TPS generating equivalent electricity.

Table 2-3: Proposed Plans for Renewable Energy Utilisation in India by 2001 AD

	Proposed Installed Capacity (in MW)	Budgetary Requirement (in Million Rs.)	Reduction in CO_2 Emissions (Million Tonnes Carbon)
Power from Biomass	6000	8000	7.79
Power from Wind	5000	7500	3.68
Power from Small Hydro	2000	4000	1.96
Energy from Sewage Sludge	50	125	0.08
Energy from Distillery	140	49	0.22
Energy from Municipal Solid Waste	160	533	0.25
Photovoltaic pumps	15	156	0.01
Windpumps	50	91	0.05

Source: Energy 2001: Perspective Plan (for) Non-conventional Energy Sources, Department of Non-conventional Energy Sources (DNES), Govt. of India, 1987.

The estimated budgetary requirements for the proposed programmes are listed in the same table (the biogas and cookstove performance, which account for nearly 70 percent of the expenditure by DNES, are <u>not</u> included in the table). Going by the financial constraints and the current trends in financial allocation, it seems unlikely that the requisite funding for the proposals will be forthcomming. As pointed out, part of this has to do with the supply oriented approach to energy planning in India which places emphasis on addition to energy production capacity.

A more rational approach to planning for energy sector requires the consideration the service provided by energy rather than energy per se. Often referred to as 'end use' planning, this method permits an analysis of the different energy conversion routes to meet energy end uses, permits the utilization of higher efficiency (both, the First and the Second Law) energy conversion paths of satisfying these end uses, allows a possible change to thermodynamically suitable fuel mix for different end uses, and can lead to energy policies which can result in a significant delinking of growth of energy consumption from development and is more likely to promote a sustainable development effort. The end use approach, in conjunction with the actual cost of delivered energy, also leads to a realistic assessment of the cost effectiveness of different source-technology-end use combinations from the viewpoint of the society. When this procedure is followed, it can be shown that even the 'expensive' photovoltaic technology is cheaper than providing the same energy service by extending the grid at many places in India. The cost-effectiveness of other commercially available renewable energy technologies for irrigation such as windmills, gasifier and biogas based dual fuel engines, biomass based Stirling engines are better and less ambiguous. The same is true for many other energy end uses such as rural lighting, motive power for many small-scale industrial requirements, medium and low temperature thermal energy requirements in both, the domestic and the industrial sector, energy for refrigeration in health care, telecommunication in remote areas, and so on. The potential of renewable energy sources and related technologies, therefore, is immense.

Availability of technology for meeting these diverse end uses is not the main problem. In India today the list of available innovative technologies based on renewable energy sources is impressive. Some of these have been discussed and many others can be listed. The major problem lies with the low priority attached to the renewable energy sector and the lack of funds earmarked for the utilization of these energy resources. For example, in the Seventh Plan period while the power sector received over Rs.3,42,700 million, the total allocation to the renewable energy sector was a meager Rs.5,200 million.

It would, however, be misleading to give the impression that all the renewable energy technologies have achieved the level of maturity or sophistication that is associated with the conventional routes to energy conversion. Here also, part of the reason can be attributed to the lack of funding to the renewable energy technologies. Therefore, the question of resource mobilisation for development of non-conventional forms of energy is critical to the whole programme in this area.

Afforestation

The Government of India has been striving to meet the stated objective of afforesting 30% of India's land area - about 328.8 million hectares (Mha). The annual planned afforestation is of the order of 5 Mha, but less than 2 Mha per year has been achieved[24] due to number of reasons, principally the lack of financial resources.

The total area under forest cover decreased from 64.2 Mha in 1985 to 64.0 Mha in 1987 as indicated by satellite imagery (reconciled with ground data) with a minimum resolution of 25 ha[25]. Consequently, deforestation, as measured by satellite imagery, is of the order of 0.1 Mha per year.

It should be noted that estimates of the rates of deforestation vary from 0.1 million hectares to 1.2 million

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[24] India's Forests - 1987, Department of Environment, Wildlife & Forests, Government of India, 1987.

[25] State of India's Forests, 1989, Forest Survey of India, Dehradun, 1989.

hectares each year. The biggest reason for deforestation is grazing, lopping and firewood collection. The demand of firewood is assessed to be around 225 million tonnes. The recorded production is only about 100 million tonnes. Thus, there is a gap of about 125 million tonnes. This is currently met primarily from the liquidation fellings. Added to this problem, the grazing pressure of around 467 million heads of livestock need about 1058 million tonnes of fodder. Most of this is collected free. At the same time, afforestation through social forestry programs has been of the order or 2 Mha per year. Most of these plantations are either in small woodlots which are less than 25 ha in area, or in strip plantations along canals, roads and railway lines. Neither of these plantations are visible through satellite imagery, and therefore could not have figured in the forest area computations. It should be pointed out that 2 Mha is not the actual area under afforestation but is notional. The area has been worked out on the basis of 2,000 plants per hectare. The actual planted area is less than 50% of the achievement shown as the planting stocking varies from 2,000 to 10,000 seedlings per hectares. Most of the land where afforestation work has been done continues to be under grazing and other uses. The actual success of plantation is very much below the targets shown to be achieved. Assuming a 50% survival rate in social forestry plantations, the net change of area under forest cover works out to between 0.2 Mha net deforestation and 0.5 Mha of net afforestation. Consequently, the situation is precarious - and distorted towards deforestation, and only massive afforestation can result in a net decrease in carbon dioxide emissions.

If the stated objective of foresting one-third of India's land area is to be achieved by 2000, 15 Mha of afforestation are required over the next 10 years. The planned afforestation is expected to be about 3 Mha per year over the next 10 years. Assuming 50% survival, the net afforestation is 15 Mha over the decade, while required afforestation is 150.

The incremental afforestation is, therefore, 270 Mha over the next 10 years. This would cost Rs.810 million. At an average wood stock of 25 tonnes per hectare, the incremental CO_2 sequestered over ten years would be about 3750 million tonnes of carbon, or 375 million tonnes of carbon per year.

If afforestation is required to be done for CO_2 assimilation, the tree cover once created must be maintained. Unfortunately in the present planting programmes there is an undue emphasis on meeting the demand of fodder and fuel. The plantations created under the previous five-year plans have mostly been used up and they do not, therefore, contribute to CO_2 assimilation. If plantations are desired to be carried out for CO_2 assimilation then the afforestation must be followed with a good system of management so that the vegetal cover once created stays on the ground. Fortunately, trees keep on increasing in the crown size. Consequently, the CO_2 assimilation per tree increases with age upto maturity of tree. A system can, therefore, be devised that afforestation can be used simultaneously for wood production as well as Co_2 assimiliation. This, however, will need a very good system of forest management. Mere afforestation and using up of the biomass so produced is not going to help the cause of Co_2 assimilation.

APPENDIX I

IDENTIFICATION AND QUANTIFICATION OF ENERGY CONSERVATION MEASURES BY THE INTER MINISTERIAL WORKING GROUP, 1983

A. INDUSTRY SECTOR

Sl. No.	Recommendation	Saving Expected: In Million Tonnes of Coal Equivalent Per Annum	Saving Expected: In Rs., Crores Per Annum	Investment (in Rs., Crores)	Remarks
	Short Term Measures				
i.	Implementation of good keeping measures	7.1	616	400	House keeping measures include tuning of combustion equipments, proper maintenance of energy consuming equipments, condensate recovery insulation, etc.
ii.	Training of industrial personnel in energy				
iii.	Introduction of system of energy audit.				
	Medium Term Measures				
iv.	Installation of waste heat recovery systems	8.9	772	1200	Investment figures indicated have to be borne by industry and government, the major portion being met by the industry
v.	Replacement of old inefficient boilers by high efficiency boilers				
vi.	Introduction of instrumentation and control systems				
vii.	Adoption of better technological innovatives like ceramic fibers low excess air burners variable speed drives, etc.				
	Long Term Measures				
viii.	Introduction of Co-generation systems	6.2	537	2000	
ix.	Adoption of newer energy efficient technologies.				
x.	Introducing computers for process control on real time basis				
	Total	22.2	1925	3600	

B. TRANSPORT SECTOR

Sl. No.	Recommendation	Saving Expected: In Million Tonnes of Coal Equivalent Per Annum	Saving Expected: In Rs., Crores Per Annum	Investment (in Rs., Crores)	Remarks
Short Term Measures					
i.	Accelerating the national programme on education campaign for users of road transport	1.68	240	200	
ii.	Enforcing speed limits and abolishing octroi checkposts	0.73	105	30	
iii.	Emulating the concept of model depots in State Transport Undertaking	0.21	30	60	
Medium Term Measures					
iv.	Adoption of energy efficient technology for new heavy vehicles, automobiles and 2/3 wheelers	a) 1.05 b) 0.31	150 90	300 200	a) For heavy vehicles b) For automobiles and 2/3 wheelers
v.	Formulating and implementing a plan for upgrading the quality of road surfaces	1.05	150	100	The investment has to be incurred on a recurring basis every year
	Total		765	890	

C. AGRICULTURAL PUMPSETS

Sl. No.	Recommendation	Saving Expected: In Million Tonnes of Coal Equivalent Per Annum	Saving Expected: In Rs., Crores Per Annum	Investment (in Rs., Crores)	Remarks
Short Term Measures					
i.	Initiating of national education and awareness programme on energy conservation in lift irrigation pumpsets			100	
ii.	Organizing programme for remedying the installation defects in the existing pumpsets	1.6	340	400	Installation defects like undersizing of suction and delivery pipes, high resistance foot valves, etc.
Medium Term Measures					
iii.	Technology development for high efficiency pumpsets and oil engines and introducing the same for new pumpsets	0.33	70	150	
	Total	1.93	410	650	