REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

(PHASE III)

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REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

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Contents

ACCELERATED HYDROELECTRIC CAPACITY ADDITION FOR LIMITATION OF GHG EMISSIONS

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Abstract

Electricity capacity additions in India during the eighth and ninth Plan periods will fall far short of planned targets, primarily because of increasing financial constraints. This would probably lead to a rapid growth of diesel-based generation capacity (in agriculture and industry) to cater to burgeoning electricity demand. It is estimated that hydroelectric capacity additions during the nineties would be about 17,965 MW as against the planned target of 33,498 MW during this period. The difference of 15,533 MW between the estimated and planned capacity additions is judged to the incremental potential of an accelerated hydroelectric power programme designed to limit the emission of greenhouse gases, particularly carbon dioxide. The cost of this additional capacity is estimated to be Rs.258 billion. Carbon dioxide emissions from the load location-based diesel generating sets providing the electrical energy equipment of 15,533 MW of grid-based hydroelectric capacity would be 66 million tonnes of carbon per year. The specific cost of carbon dioxide emission limitation due to the accelerated hydroelectric programme is, therefore, Rs.3,909 per tonne of carbon. In addition, the current requirement of afforesting an area twice in size of forest land area which is affected by hydro power projects will serve to further sequester atmospheric carbon.

Introduction

The total potential for economic hydro electricity in India is about 600 TWh of firm annual electric energy which is the equivalent of 85,000 MW of installed capacity at 60% load factor. Assuming that hydro power plants of various types would be operating at an energy load factor of about 40%, the installed capacity would be about 125,000 MW. Out of this available potential, only about 20% (18,566 MW) have presently been exploited with the completion of projects up to the end of the 7th Plan. Thus, a vast hydro potential remains to be developed. In addition to this conventional hydro power potential, the Central Electricity Authority (CEA) has also identified a number of pumped storage hydro schemes totaling about 96,000 MW in various regions of the country[1].

The share of hydro electricity in the current mix of installed capacity in the country is about 33%, considerably less than the recommended share of 40%[2]. During the eighth and ninth plans, a total addition of 102,884 MW of installed capacity was envisaged by the 8th Plan Working Group on Power[3], of which additional planned hydroelectric capacity was 33,498 MW. Table 1 shows the Working Group's planned capacity addition targets. In the past three years, however, these targets have been progressively reduced with increasing constraints on budgetary resources, and presently firm financial commitments are available only for 20,736 MW of capacity addition during the 8th Plan period, of which 5,273

MW is hydroelectric capacity. The Working Group, on the other hand, had planned for total capacity addition of 38,781 MW during the Eighth Plan, of which 8,135 MW would have been hydroelectric capacity. Given the constraint on resources, it is also unlikely that the 9th Plan targets would be met.

Table 1: Capacity Addition Targets During the Nineties

Region	Capacity Addition During the 8th Plan				Capacity Addition During the 8th Plan			
	Thermal	Hydro	Nu-clear	Total	Thermal	Hydro	Nu-clear	Total
Northern	7424	2836	235	10495	6446	11676	2470	20592
Western	7887	2299	470	10656	8300	4893	1470	14663
Southern	5963	1660	-	7623	9920	2855	4940	17715
Eastern	7375	1307	-	8382	4600	3514	-	8108
North-Eastern	1292	33	-	1625	600	2425	-	3025
All India	29941	8135	705	38781	29866	25363	8880	64103

Source: Report of the 8th Plan Working Group on Power, Planning Commission, Government of Indian, 1988.

Expected Hydroelectric Capacity during Nineties

Expected additions to installed capacity are no longer correlated to planned targets due to financial constraints. However, it should also be pointed out that the 8th Plan Working Group targets called for much more rapid capacity addition than did previous plan targets. Typically, hydroelectric capacity has grown at a rate of about 6% per annum, whereas the 8th Plan Working Group envisaged a near 11% annual growth rate during the nineties. It is hypothesized here that future growth will follow the same trend as historical growth because of overall macroeconomic limitations.

Figure 1 shows the growth of hydroelectric power in India. Assuming that future growth continues at the same rate (approximately 6% per annum), the addition during the 8th Plan period would be 7780 MW, and 10,185 MW during the 9th Plan. Consequently, the total hydroelectric installed capacity in the country at the end of the 9th Plan period (1990-2000) would be 36,531 MW.

This expected capacity addition during the nineties (17,965 MW) is substantially less than the 8th Plan Working Group's capacity addition target of 33,498 MW during the same period. Consequently, there is a potential for a further installation of 15,533 MW of hydroelectric power by the year 2000 if capital is available.

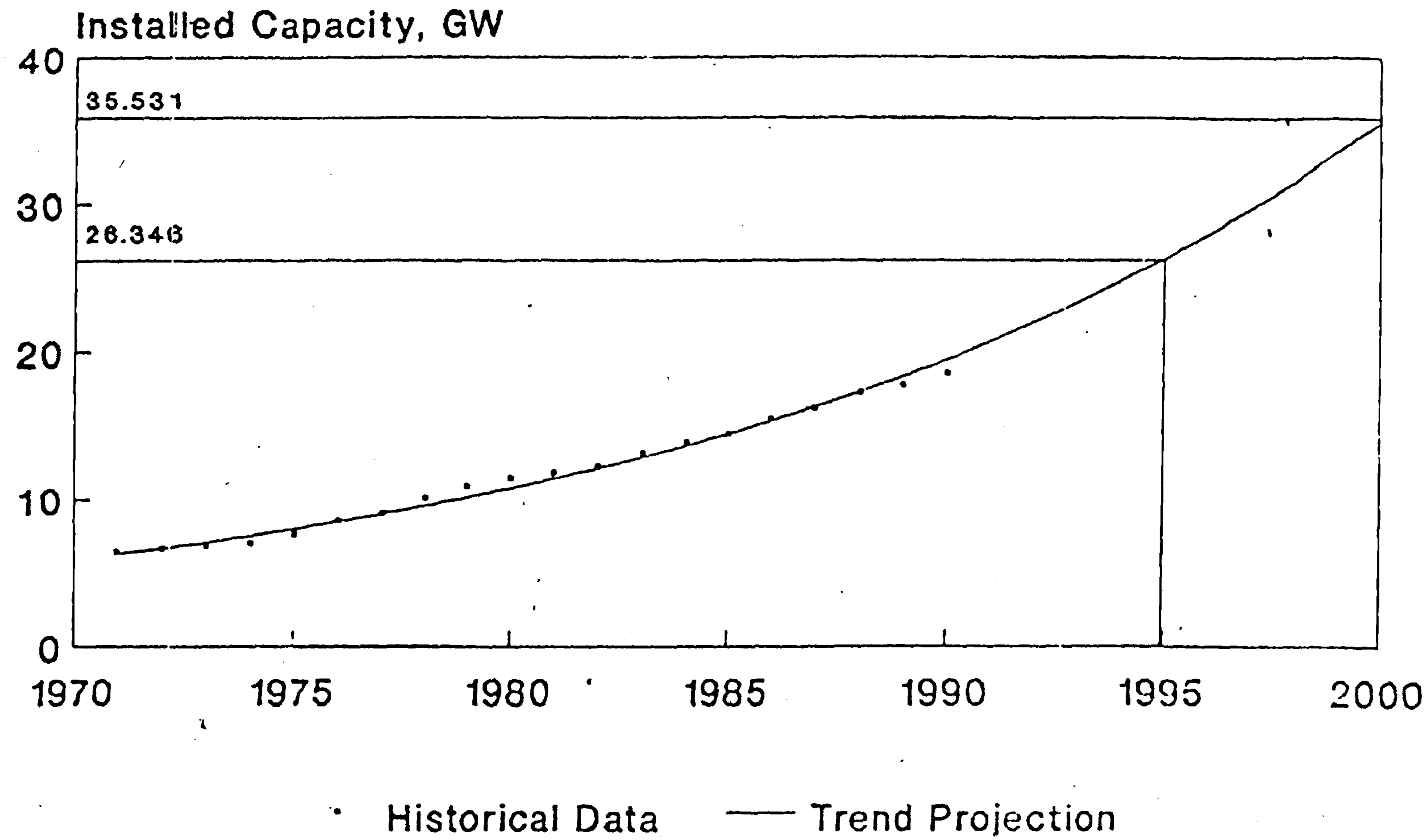
Costs of Hydroelectric Power

The installed cost of hydroelectric projects varies widely, and most experts prefer a location-specific and head-specific cost estimate. To a first approximation, however, a specific cost for hydro electricity would be desirable so as to assess the total incremental cost of the addition of a further 15,533 MW of hydro power by 2000.

Table 2 lists the costs of recently approved hydro power projects[4]. The costs of these projects have been updated to 1990 costs here and the specific costs at 1990 prices are also shown in Table 2. Barring four instances, the specific costs range between Rs.14,074 and Rs.21,051 per kWh of installed capacity. Of the four projects outside this

Figure 1

Installed Hydroelectric Capacity in India



Source: CEA, Public Electricity Supply, All India Statistics, General Review 1986-87, Government of India, 1990.

cost range, one is the Sardar Sarovar project, whose costs are almost certainly going to be much high than those estimated in 1984 because of increased cost of rehabilitation. On the other hand, the highest specific cost is that of the project with the lowest installed capacity (Dadupur Hydro Power Project (HPP) with an installed capacity of 4 x 1.5 MW). The two other projects which have considerably lower costs (Nagarjunsagar Right Canal HPP and Kakkad HPP) are both extensions of existing projects in which the capital costs are much lower than for new projects because of existing infrastructure.

Table 2: Capital Cost of Hydro Power Projects

Project	Installed Capacity (MW)	Cost of Project (million Rs.)	Year of Approval	Current Cost (1990 prices) (million Rs.)	Specific Cost (Rs./kW)
High Head					
Andhra	3x5	97.4	1976	295.2	19677
Bairasul	3x60	922.2	1977	2634.9	14638
Sanjay Vidyut Pariyojana	3x40	1256.2	1983	2129.2	17743
Puyankutty	2x120	2500.0	1984	3968.3	16534
Likim	3x8	464.8	198	505.2	21051
Medium Head					
Kakkad	2x25	186.0	1976	563.6	11273
Umiam-Umtru Stage IV	2x30	387.9	1978	994.6	16577
Doyang	3x35	963.1	1981	1926.2	18345
Sawalkot	3x200	6869.1	1985	10407.7	17346
Larji	3x42	1688.5	1986	2483.1	19707
Low Head					
Nagarajunasagar Right Canal	2x30	181.9	1977	519.7	8662
Lower Mettur	8x15	836.0	1978	2143.6	17863
Dadupur	4x1.5	74.1	1981	148.2	24700
Sardar Sarovar	6x200 + 5x50	10634.0	1984	16615.6	11459
Satanur	2x75	1520.0	1987	2111.1	14074

Source: T.R. Satish Chandran, "Economics of Power Generation: Issues and Choices", in Electrical Energy and Environment, Indian National Academy of Engineering, New Delhi, 1990

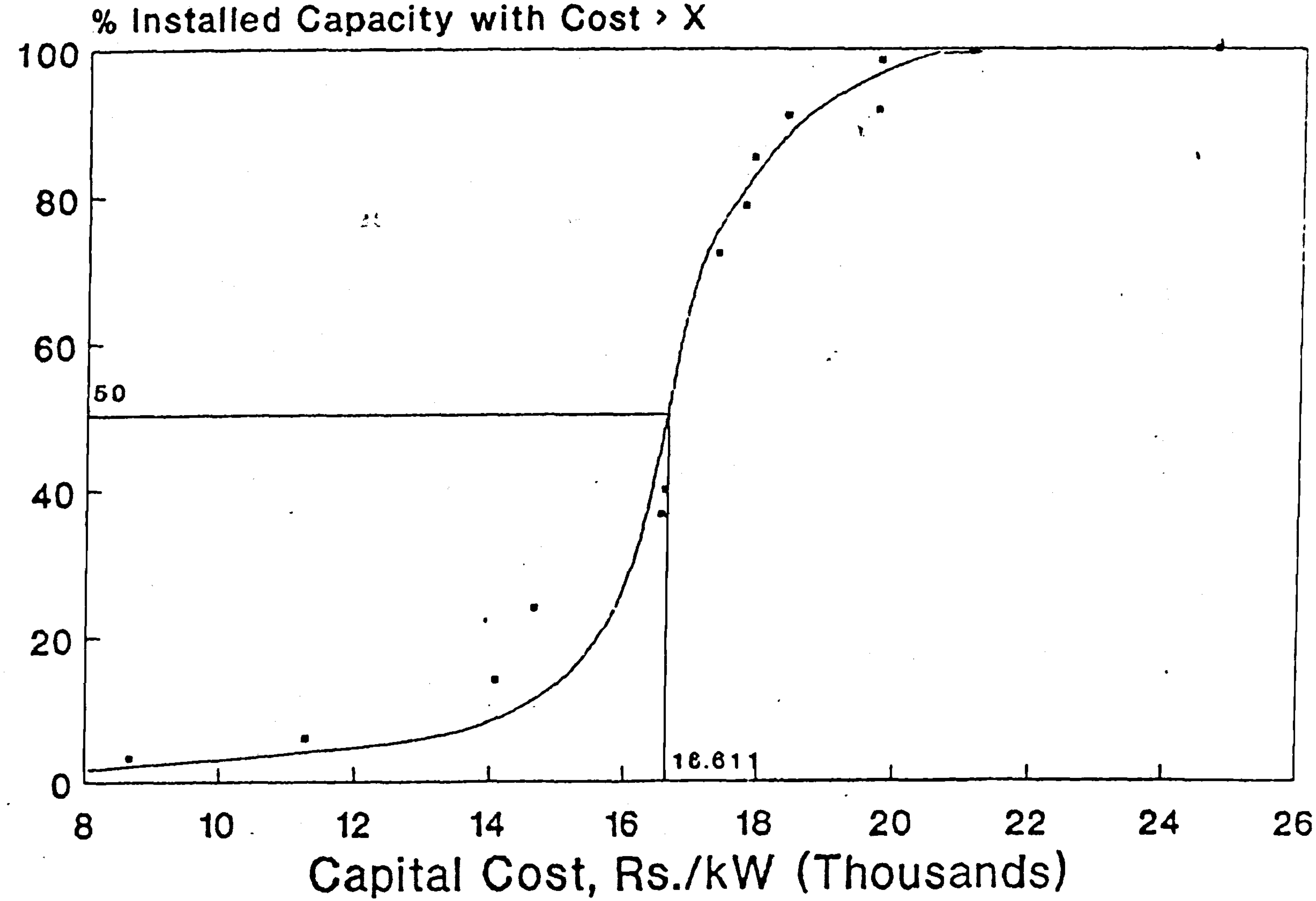
This sample (with the exception of Sardar Sarovar Project for which the cost specified in Table 2 is certainly not the final approved cost) can, therefore, be considered representative of the various types of hydroelectric schemes that will be built in the country. Figure 2 shows the cumulative cost distribution of the projects in the sample (with the exception of the Sardar Sarovar Project). The specific project cost is plotted on the horizontal axis, and the percentage of total installed capacity in the sample with specific cost less than the specific cost on the horizontal axis is plotted on the vertical axis. Figure 2 shows that only 10% of capacity costs less than Rs.14,000/kW, and almost all capacity costs less than Rs.21,000/kW. The median project cost is Rs.16,611/kW.

Consequently, for future hydroelectric projects, an average cost of Rs.16,611 per kW seems to be an appropriate first-cut approximation. The incremental cost of an accelerated hydro electric programme aimed at adding an extra 15,533 MW of hydro electric capacity by 2000 (beyond that considered feasible under the present economic situation) would be Rs.258 billion.

CO_2 Emission Reduction Due to Hydroelectric Projects

The 8th Plan Working Group report set targets for installed capacity addition based on projected demand for electricity. The reduction in capacity addition due to capital constraints would not decrease electricity demand, but would instead probably lead to an increased use of diesel-based generating

Cost Distribution of Hydro Power Projects



All costs are at 1990 prices

Figure 2

sets in industry and in agriculture. It is assumed here that the accelerated hydro electricity programme would reduce the addition of this diesel-based generation.

Based on current performance level of hydroelectric projects, a 1,000 MW HPP would provide 3.29 GWh of electric energy annually to the grid (based on a net generation level of 3291 kWh per KW of installed hydro capacity[5]). With 22% T&D losses, the electric energy supplied to a consumer from the 1,000 MW HPP would be 2.56 GWh. To generate equivalent electricity from diesel-based capacity, 6.633 million liters of diesel would be required annually. This estimate is based on a diesel requirement of 0.37 liters per kWh generated and auxiliary consumption of 4.27%[5]. The CO_2 emissions resulting from these diesel use would be 4.25 million tonnes of carbon (Mt C).

Consequently, carbon dioxide emissions would be limited by 66 Mt C due to addition of 15,533 MW of hydro power at a cost of Rs.258 billion. Specific cost of CO_2 emission limitation, therefore, works out to Rs.3,909 per tonne of carbon.

Carbon Sink Loss Due to Submergence

Most hydroelectric projects are located in regions which are rich in forests, and some of forest area is almost always submerged due to the construction of river valley projects. A total of 0.502 million hectares of forests land was submerged between 1951 and 1980 due to the construction of dams and reservoirs for HPPs[6]. The total contribution to this area to carbon dioxide sequestration would be a maximum of 2.25 million tonnes of carbon per annum (based on an annual growth of 10 tonnes of wood per hectare, with a 45% carbon content). In addition, if all the wood in the reservoir area was burnt before submergence, about 22 tonnes of carbon would be released per hectare, implying a total emission of 11 million tonnes of carbon. This emission is accounted for in historical data as carbon dioxide emissions from land use changes.

After 1980, all projects (including HPPs) which require forest land are required to afforest an area which is double the forest land area acquired, and project costs include the cost of this afforestation. For example, Table 3 shows afforestation programmes associated with NHPC projects[7]. It can also be argued that new plantations sequester carbon at a more rapid rate than mature forests, and consequently the overall absorption by plantations would be higher than the carbon sink loss due to forest submergence. There is, of course, a difference in time scales - plantations will sequester carbon at a latter date whereas the sink would be removed earlier. However, to a first approximation, it can be assumed that the submerged forests and new plantations balance out the loss and gain of carbon sinks.

Table 3: Afforestation Programmes of NHPC Projects

Sl. No.	Name of the Project	No. of Trees Affected	No. of Trees to be Planted	Schedule of Plantation	Plants Planted So Far	Plants Survived
1.	Chamera	40,000	46,00000	1984 to 1995	23,92,242	13,58279
2.	Dulhasti	687	2,00000	86087 to 88-89	4,64,662	2,80,000
3.	Uri	4,000	3,14000	86-87 to '70-71	1,56,000	93,600
4.	Dulhasti Trans.	9,000	20,00000	87-88 to 92-93	4,21,150	3,11,935
5.	Uri Trans.	4,400	6,60000	88-89 to 92-93	98,550	97,844
6.	Tanakpur	17,368	8,75000	88-89 to 92-93	3,24,800	3,24,800
7.	Salal*	-	-	-	6,14,876	3,96,481
8.	Loktak*	-	-	-	2,81,150	2,14,920
9.	Baira Siul*	-	-	-	1,59,519	-
	Total				49,12,949	30,77,859

*Voluntary Afforestation

Source: M A Hai, B S K Naidu and D C Purohit, "Hydroelectric Power and Environment", in Electric Energy and Environment, Indian National Academy of Engineering, New Delhi, 1990.

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