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HYDROPOWER IN THE NORTHEAST: POTENTIAL AND HARNESSING ANALYSIS

BY

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Table of contents

Tables

Figures

Boxes

Acknowledgments

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1. Background

Development of the Northeast is receiving priority attention from the Government of India, both for the well-being of the people of the region and for its potential contribution to the Indian economy, and to the fostering of links and economic relations with neighboring countries.

Within that context, the World Bank has instituted a study on the hydropower potential of the Northeastern Region of India, and the options for harnessing that potential, as a part of the wider study on Natural Resources, Water and the Environment Nexus for Development and Growth in Northeast India. The main objectives of the hydropower study are to provide:

- An analysis of the hydropower potential in the Northeast and key elements of the strategy that should be followed for optimal realization of this potential
- An overview of the hydropower development options in the Northeast with regard to the water resources in the different river basins, including consideration of flood control and irrigation.

Towards these objectives, several issues concerning water resources, hydropower development, and power sector development, at present and in the future, were analyzed and a course of action charted. The terms of reference are provided in appendix 1. Specific issues considered include hydropower development in the Northeastern Region within the national context; the issues in development of hydropower potential, and the various benefits and disadvantages of such development; identification of hydro and multipurpose schemes for implementation over the next 10 to 15 years; estimated costs; and implementation strategy.

2. Context and setting

Electricity is recognized as fundamental to industrialization and improving the quality of life of the people. Harnessing the immense untapped hydropower potential in the Northeastern Region opens avenues for growth and provides an opportunity to improve the well-being of the people of the region, while making substantial contribution to the national economy. Though identified in the early years after independence, the large hydropower potential of the Northeastern Region has remained mostly unexploited for a variety of reasons, such as the status of development of the grid systems in the country, availability of economic and accessible sites near to the load centers in the other regions of the country, low demand for power in the sparsely populated Northeastern Region, and considerations regarding the impact of hydropower development on the livelihoods of the indigenous population, the river ecosystem, and the safety of dam construction in this seismically active zone.

Power sector development and public utility supply in the country had its beginnings in 1897 with a small hydropower plant near Darjeeling (West Bengal), close to the Northeastern Region. From this humble beginning the power sector has registered impressive growth, particularly since independence in 1947, and in the era of planned power development. From a meager 1,362 megawatts at the time of independence the installed capacity in the country has risen to 118,419 megawatts (as at the end of March 2005). Despite this growth, all the power regions of the country (identified in table 1) have been facing widespread shortages for some years, including during 2004–2005, when the countrywide shortage was to the extent of 11.7 percent in peaking capacity and 7.3 percent in energy (figures 1 and 2; appendix 2). The power shortage in the

Northeastern Region was at about the same level (11.3 percent in peaking capacity and 6.3 percent in energy) as that of the country as a whole. The actual shortages would be higher, particularly the peak shortages, if unscheduled power cuts and various control measures were taken into account. The situation in the Northeast is also further constrained by the inadequacies in transmission, subtransmission, and distribution.

The development of the electricity grid systems and planning of generation capacity addition in the country has so far been on the basis of the five regions – each comprising a group of contiguous states – shown in table 1. The Northeastern power region comprises the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, popularly known as the Seven Sisters. A map of the northeastern states showing the river basins is given in figure 3. For the purposes of this study, the state of Sikkim (which is a constituent of the Eastern regional grid) has been considered part of the Northeastern power region. The published power sector data, however, are based on the power regions of the country, with Sikkim in the Eastern power region.

Table 1. India: States making up power regions

Region	States and union territories
Northern	Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Rajasthan, Delhi, Chandigarh, Uttaranchal, Uttar Pradesh
Western	Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh, Goa
Southern	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Pondicherry
Eastern	Orissa, Jharkhand, Bihar, Damodar Valley Corporation, West Bengal, Sikkim
Northeastern	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura

Figure 1. Power shortages in India 2004–2005

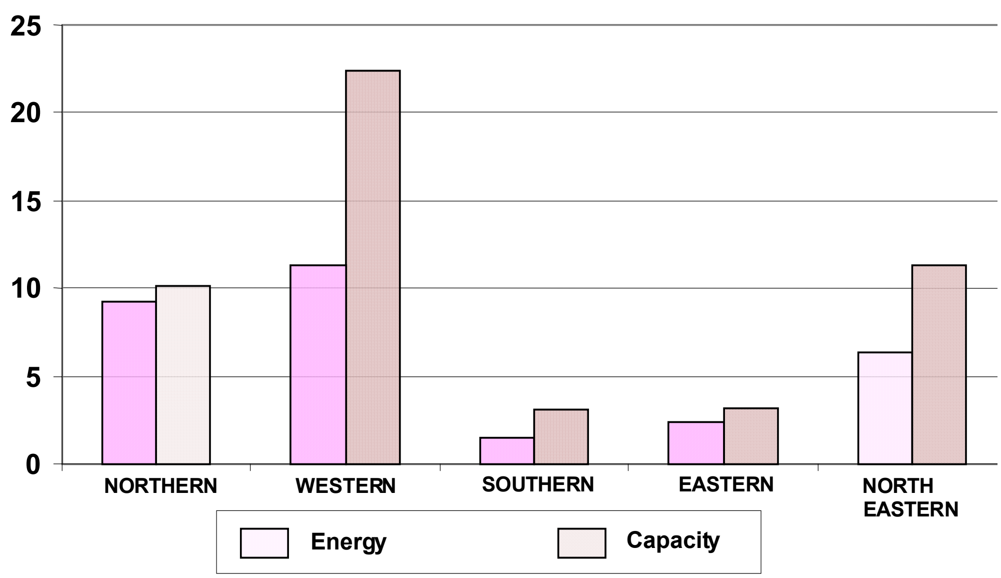
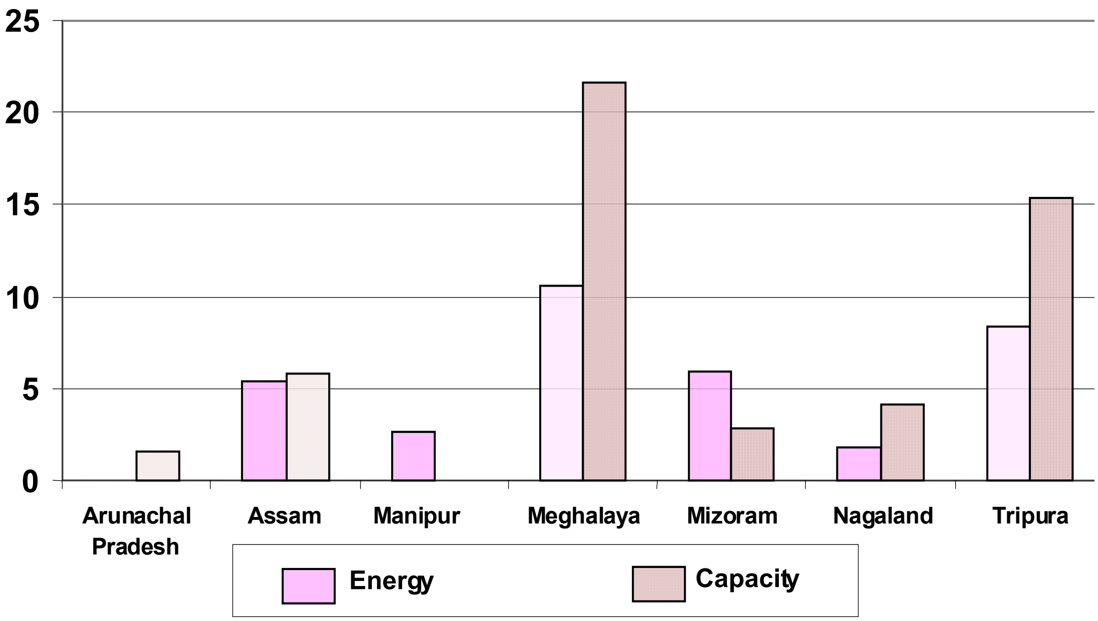


Figure 2. Power shortages in Northeastern power region 2004–2005



The details of installed capacity for each power region (as on 31 March 2004), by type of plant (hydro, thermal, and other) and by ownership (central, state, private), are given in figure 4 and appendix 3A. India's present installed hydro capacity of 30,935 megawatts is 26 percent of national potential capacity, well below the desirable optimum level of 40 percent. The central sector contribution to this total is 6,053 megawatts (19.6 percent) – 16 percent of the total installed capacity for which the central sector is responsible. The Southern and Northern power regions contribute about one-third of the total hydro capacity. The Western and Eastern power regions are predominantly thermal based, with only 17 percent and 13 percent respectively of the installed national hydro capacity. In the Northeastern power region, hydro contributes about 48 percent of the total installed regional capacity.

Figure 5 and appendix 3B give installed capacity details for the states of the Northeastern power region and Sikkim. Total installed capacity is 2,419 megawatts, about 2 percent of the national total. The central sector contributes 52 percent of the total capacity and 75.8 percent of hydro capacity in the region. In terms of total energy generation, the region's contribution (2003–2004) was 6,669 gigawatt-hours (net at bus bars), which constituted 1.2 percent of the total generation in the country (525,300 gigawatt-hours).[1]

[1] Detailed data for the power sector as a whole are available only for the year 2003–2004.

Figure 3. Map of Northeastern Region showing river basins

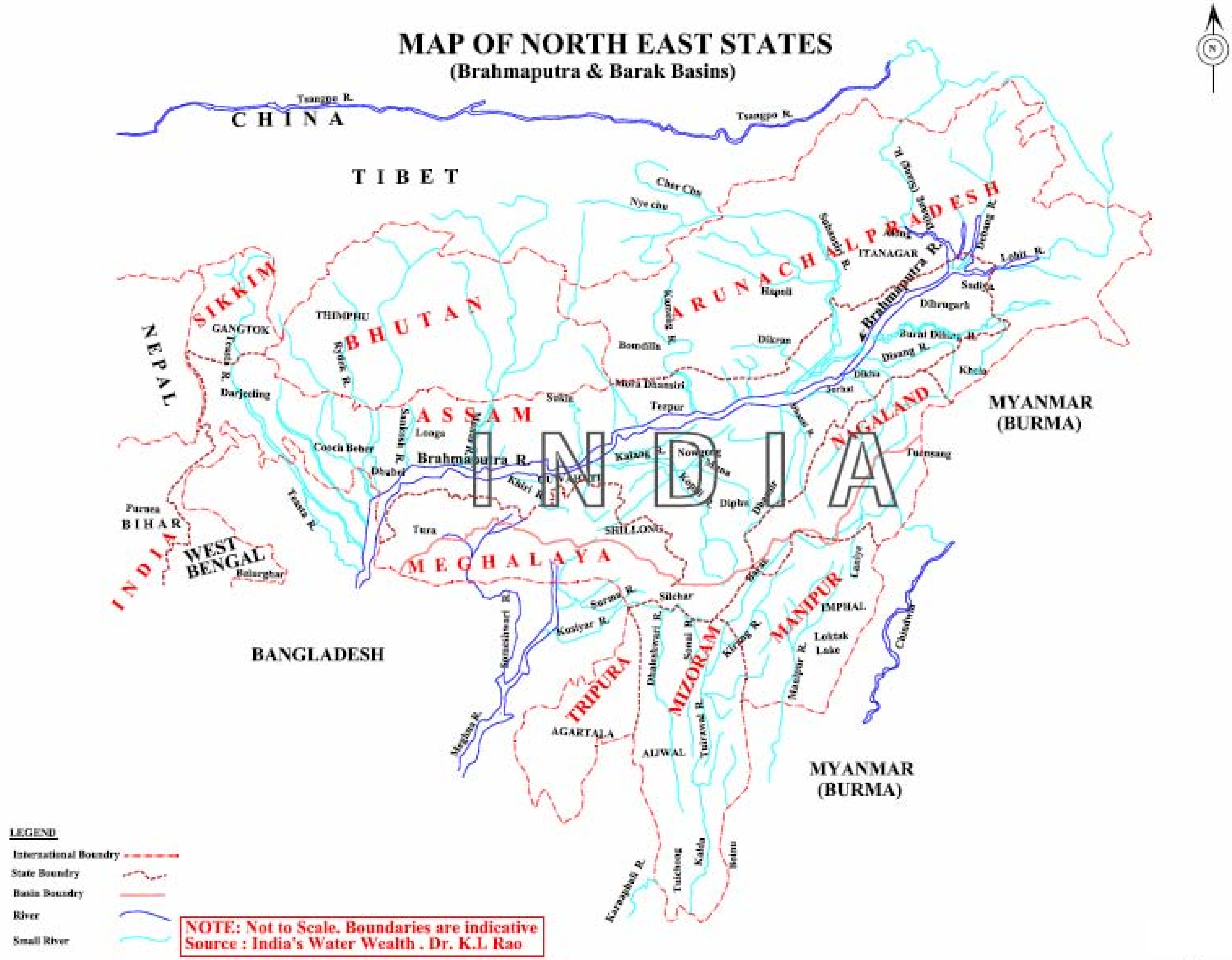


Figure 4. India: Installed capacity of types of power by power region

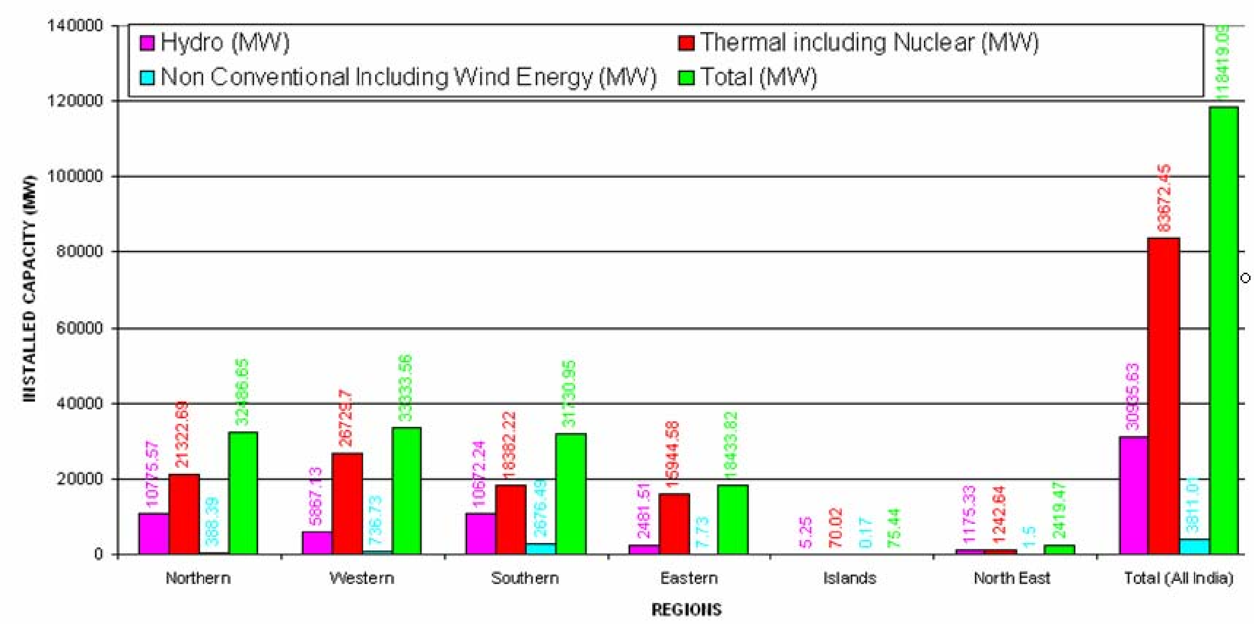
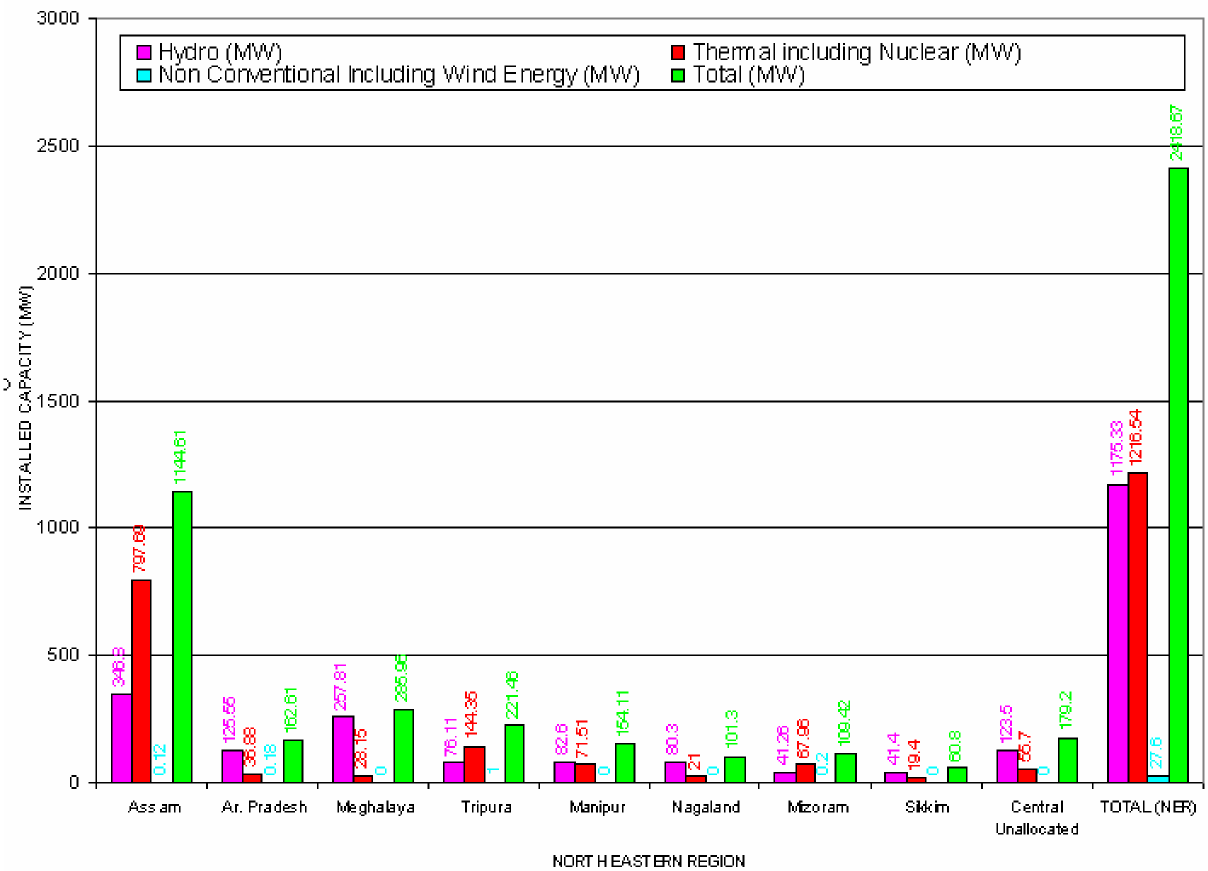


Figure 5. The Northeast: Installed capacity of types of power by state



Transmission and distribution losses in the Northeastern power region and Sikkim were 38.64 percent, highest among the regions and above the national average of 32.53 percent. In six of the eight states the losses were in the range 45–65 percent. In Assam and Meghalaya the losses were 39.3 percent and 16.3 percent.

The pattern of consumption of electricity in the Northeastern power region is largely in the domestic and commercial sectors (45 percent of total). The industrial consumption of 1,200 gigawatt-hours is less than 1 percent of the total industrial consumption (124,573 gigawatt-hours) of the country.

The annual per capita consumption in the region is 119 kilowatt-hours compared to 390 kilowatt-hours for the country. Using United Nations methodology to calculate total gross generation, the annual per capita consumption in the region is 192 kilowatt-hours, which is about one-third of the national consumption of 592 kilowatt-hours.

Village electrification in the Northeastern power region, at 76.6 percent of the total villages (29,696), is lower than the national average of 84.3 percent. Nagaland and Sikkim are the only states in the region where all villages have been electrified so far. This is followed by Mizoram (99.6 percent), Tripura (95.9 percent), Manipur (95.5 percent), Assam (77.3 percent), Arunachal Pradesh (63.5 percent), and Meghalaya (63.5 percent). These village electrification data are based on the old definition in which a village was taken as electrified if electricity was used anywhere for any purpose in the revenue boundary of the village. The definition was modified in February 2004 to give emphasis to household electrification (box 1).

Box 1. Definition of village electrification

Old definition:

"A village will be deemed to be electrified if electricity is used in the inhabited locality within the revenue boundary of the village for any purpose whatsoever."

(Notification issued by Ministry of Power, 28 October 1997)

New definition:

"A village would be declared as electrified if:

(i) Basic infrastructure such as distribution transformer and distribution lines are provided in the inhabited locality as well as the dalit basti/hamlet where it exists. (For electrification through nonconventional energy sources a distribution transformer may not be necessary).

(ii) Electricity is provided to public places like schools, panchayat offices, health centers, dispensaries, community centers, etc.

(iii) The number of households electrified should be at least 10% of the total number of households in the village.

Mandatory certification from Gram Panchayat regarding the completion of village electrification should be obtained."

(Notification issued by Ministry of Power, 5 February 2004)

The village electrification data as per the latest definition has yet to be recast. The rural household electrification of 24.3 percent in the Northeastern power region is well below the national average of 43.5 percent. The level of household electrification (Arunachal Pradesh 44.5 percent, Manipur 52.5 percent, Mizoram 44.1 percent, Nagaland 56.9 percent, and Sikkim 75.2 percent) is higher than the national average, except in the states of Meghalaya (30.3 percent) and Assam (16.5 percent). Village and household electrification in the Northeast is a factor to be considered in the strategy framework for hydropower development of the region.

The irrigation pump sets and tubewells energized totals only 6,900 and constitutes about 2 percent of estimated potential of 336,800 in the region.

The salient power sector parameters discussed above are presented in appendices 4 and 4A. In brief, the major power sector indicators reflect the relative poverty of the Northeastern Region of India compared to much of the rest of the country.

3. Northeastern Region

3.1 Physical features

The Northeastern Region of India includes the states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and Assam, which forms the heart of the region (see figure 3). The region has international borders with China in the north and east, with Bhutan located between the states of Sikkim and Arunachal Pradesh. The other states of the region have borders with Bangladesh and Myanmar on the south and east. Assam and Tripura occupy the plains while the rest of the states are mostly mountainous (with wide variations in slopes and altitudes), with much rugged and inaccessible terrain. The western part of the region is connected to the eastern part of the country through a narrow land corridor (with Bhutan to the north and Bangladesh to the south) – the Siliguri corridor, popularly referred to as the Chicken's Neck.

3.2 Geographic and forest features

The total geographic area of the Northeastern Region is 26.22 million hectares out of the total of 329 million hectares of the country. The northeastern states have 143,348 square kilometers under forest cover, which constitutes 64.6 percent of the total geographic area (State Forest Report 1997). Important forest species found in the region include *Dendrocalamus hamiltonii*, *Gmelina arborea*, *Shorea robusta*, *Vitex peduncularis*, *Terminalia belerica*, *Emblica officinalis*, *Schima wallichii*, and *Bauhinia purpurea*. A wide variety of tree species are of economic importance; there are also many varieties of grasses, bamboos, and canes. The region has been declared a biodiversity hotspot by Conservation International.

3.3 Climatic features

The climate of the region varies from subtropical to extreme alpine. Mean minimum and maximum temperatures vary between 18°C and 32°C in summer and 0°C and 22°C in winter. Heavy fog is a common feature all over the mountain area throughout the year. Temperatures in the snow-clad mountains in the north are below freezing for much of the year. These hill states receive the greatest rainfall in the country, with mean annual rainfall varying from 1,400 millimeters to as high as 6,000 millimeters in Arunachal Pradesh. Cherrapunji (Meghalaya) is one of the wettest places in the world, with an average annual rainfall of more than 11,000 millimeters.

3.4 Physiographic features

On the basis of topography, rainfall and temperature, soil type, cropping system, and geographic continuity and proximity, the Northeastern Region can be classified into three broadly homogeneous subregions:

- Himalayan hills of Sikkim and Darjeeling
- Hills of Arunachal Pradesh, Meghalaya, Nagaland, and Assam
- Southern hills and valleys of Manipur, Tripura, and Mizoram

3.5 Geological features

Geologically, the Northeast and the adjoining region constitute a complex geological province with convergence of two Tertiary mobile belts, the east-west Eastern Himalaya and the north-south Patkai, Naga, Manipur, Chin, Arakan, and Yoma hill ranges (of Indo-Burmese origin), developed as a consequence of the collision between the land masses of India and Asia and subsequent subduction. These two belts are truncated to the northeast by the northwest-trending diorite-granodiorite complex of the Mishmi massif. In the core of these mutually orthogonally disposed mobile belts lies the Archaean-Proterozoic cratonic elements of the Meghalaya plateau and the Mikir Hills, with Cretaceous to recent shelf-platform sedimentary cover on the southern margin of the Meghalaya plateau.

The Shillong (Meghalaya) massif is the oldest northeastern promontory of the Indian shield, which occupies a crucial tectonic position between the Himalaya in the north and the Indo-Burmese arc to the east. This massif is the only landmass that existed in the region before the breakup of Gondwanaland during the Jurassic period. The plateau consists of high-grade gneissic complex, overlain by mildly deformed Proterozoic intracratonic sediments of the Shillong group with metavolcanic Khasi greenstones, both indented by Upper Proterozoic and late Precambrian granite plutons.

3.6 Seismicity

The seismicity of the Northeastern Region is a critical issue that needs to be adequately addressed in any water resource development project. The region lies at the junction of the Himalayan arc to the north and the Burmese arc to the east and is one of the six most seismically active regions of the world. In the last 100 years as many as 18 large earthquakes have been recorded from this seismotectonic domain, two of which – in 1897 and 1950 – were among the most powerful recorded globally. Multipurpose water resource projects and hydroelectric projects built in the Northeast have generally taken seismic factors into account in their design. The argument that high dams should not be built in the high seismic zones in the Himalayas, a highly dynamic tectonic region, has been countered by leading scientists, engineers, and journalists citing examples of dams built in several countries in similar seismotectonic conditions. Dams can be designed to withstand the peak stresses caused by earthquakes by modified dam footing design, by reinforcing the dam structures, and by the use of site improvement techniques such as dynamic compaction dewatering, vibroflotation, and the use of geosynthetics. Box 2 presents the relevant observations of a scientist and of the Brahmaputra Board.

Box 2. Building dams in zones of high seismicity: Some opinions

"The argument that dams should not be built in highly seismic zones is not only unsound from the point of view of the national economy, but is also not supported by the trends of seismic activity as in the case of high dams built in similar regions elsewhere."

H. N. Srivastava, geologist, in *Forecasting Earthquakes*, National Book Trust, New Delhi

"Given adequate care, state-of-the-art research and instrumentation, and rigorous monitoring, large or small dams may be constructed with reasonable assurance of safety in hazardous areas. The fact of risk, whether from seismcity or flood or whatever, is no reason to avoid construction of dams. It implies a higher order of design safety and surveillance and preparedness to bear the attendant costs. Certain dams should be obviously not be built in any circumstances-where the risks or the costs of overcoming them are too high. In all other cases, not to go ahead would be to mortgage the future."

B.G. Verghese, in *Waters of Hope - Himalayan–Ganga Development for a Billion People*, Center for Policy Research, New Delhi, 1990

"Scientific developments and the advancement of knowledge have enabled high dams to be built with confidence at Nurek and Rogun (325 m high) in the Soviet Union, Sussodha in Alaska (280 m) and Mica in Canada (245 m high) although they are located in highly seismic zones."

Dr Jai Krishna, Earthquake Expert and author, in "Seismic Environment for Brahmaputra Valley Projects", Master Plan of Barhmaputra Basin, 1986

"The advisability of building high dams in this region which is prone to severe earthquakes has been under serious consideration and several experts of international repute, both Indian and foreign, have been consulted in the matter. Their advice has been that safe high dams can be constructed at suitable sites provided due allowance is made for the seismic factor in designing the various structures."

Master Plan of Brahmaputra Basin Part I, Appendix VIB, Brahmaputra Board, Ministry of Water Resources, New Delhi, 1986

3.7 Socioeconomic indicators

From the point of view of socioeconomic indicators, the Northeastern Region does not compare well with the rest of India. It may be seen from table 2 that the annual per capita income of the region as a whole is Rs. 6,625, compared to the national per capita income of Rs 10,254.[2] Of the total population of just over 39 million, 34.28 percent live below the poverty line, compared to the national average of 26.1 percent of the total population of 1,027 million. Population densities in the northeastern states is generally low, except in Assam and Tripura.

An Asian Development Bank study on providing technical assistance to India for preparing the Northeast Power Development project (December 2004) observed that "The North Eastern Region (NER) is one of the poorest regions in India, despite its considerable natural resources (water, gas, coal and oil, among others), and its strategic location, bordering countries in both

[2] Conversion: 1 US dollar = 44 Indian rupees (February 2006).

the Association of Southeast Asian Nations (ASEAN) and the South Asian Association for Regional Cooperation (SAARC). Limited access to basic infrastructure facilities and services, economic insularity, political instability, and lack of both connections within the region and private investment are the main causes of the NER's high level of poverty."

Table 2. States of the Northeast: Selected population and natural resource indicators

State	Population Number of people 2001	Total area Square km	Population density Persons per square km 2001	Forest cover % of total area 2001	Rural population % of total population 2001	Per capita income 2001 Per capita net state domestic product	Persons living below poverty line % of total population 1999–2000
Arunachal Pradesh	1,091,117	83,743	13	81.3	79.6	9,013	33.47
Assam	26,638,407	78,438	340	35.3	87.3	6,157	36.09
Manipur	2,388,634	22,327	107	75.8	76.1	8,745	28.54
Meghalaya	2,306,069	22,429	103	69.5	80.4	8,460	33.87
Mizoram	891,058	21,081	42	83.0	50.5	—	19.47
Nagaland	1,988,636	16,579	120	80.5	82.3	8,726	23.67
Sikkim	540,493	7,096	76	45.0	88.9	9,816	36.55
Tripura	3,191,168	10,486	304	67.4	83.0	6,813	34.44
Total	39,035,582	262,179	149	64.6	85.0	6,625	34.28
India	1,027,015,247	3,065,027	324	20.6	72.2	10,254	26.10

— Not available.

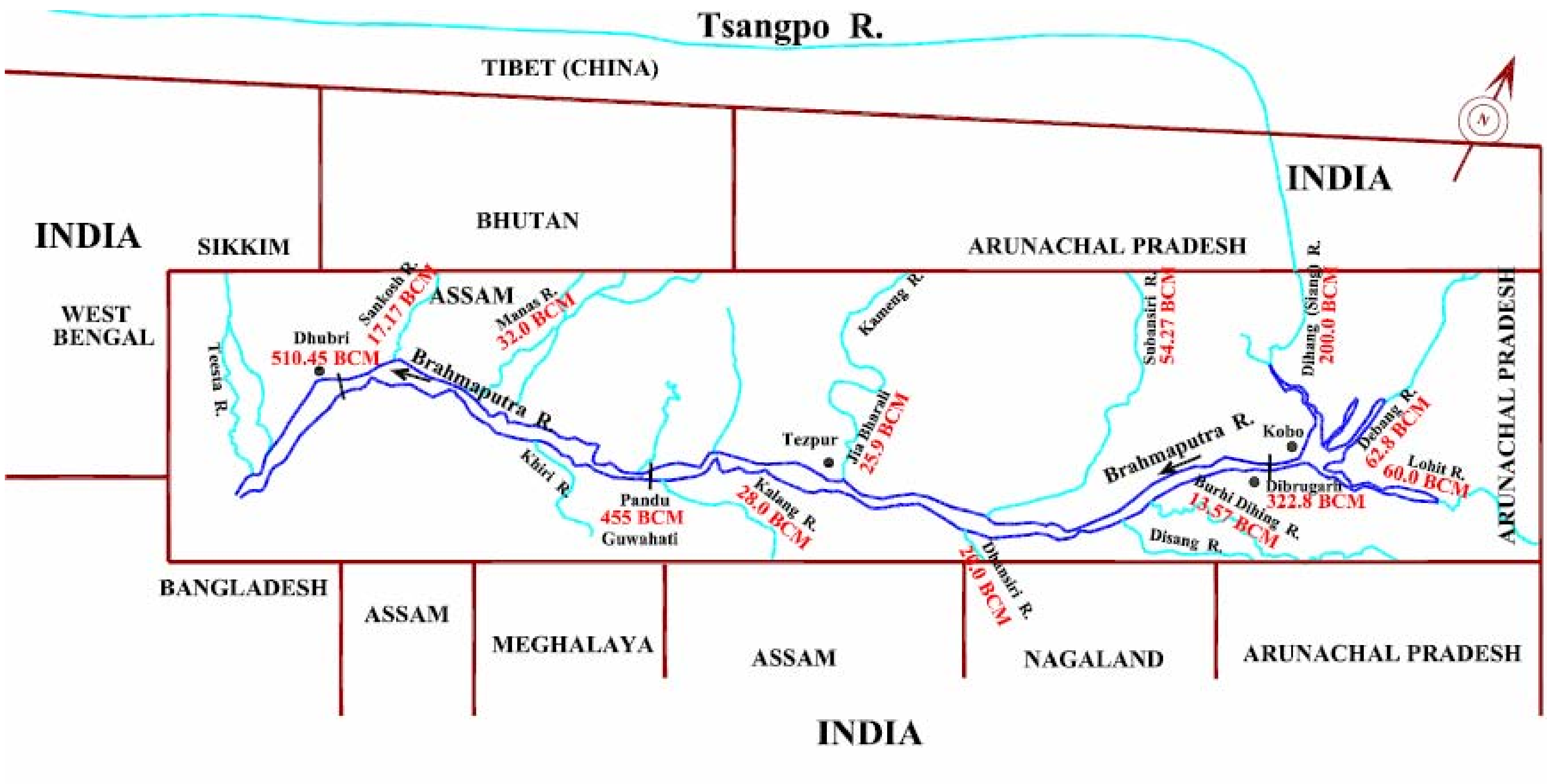
Source: www.indiastat.com.

3.8 Surface water and hydropower resources

The major river systems of the Northeastern Region are the Brahmaputra and the Barak (joining the Brahmaputra in Bangladesh). This river system drains a catchment area of 238,473 square kilometers, which is 7.25 percent of the geographic area of India (figure 3). The surface water potential of the Brahmaputra and Barak river system accounts for 31.35 percent (586 out of 1,869 billion cubic meters) of the total average annual surface water of the country. A schematic map showing the Brahmaputra river system and the average annual flows is given in figure 6. The hydropower potential of this river system constitutes 41.55 percent (34,920 out of 84,044 megawatts) of the total hydropower potential of the country. The hydropower potential of other river systems of the Northeast, for example the Kolodyne and Manipur (in Mizoram and Manipur) draining into Myanmar, and the south-flowing rivers (of Meghalaya and Tripura) draining into Bangladesh, is included in the potential for the Brahmaputra. This large water resource and hydropower potential could contribute significantly to the national water and power requirements of the country.

Figure 6. Schematic map of Brahmaputra system and average annual flows

Source: Dr. K. L. Rao, *India's Water Wealth*



3.9 Groundwater resources

The region has a total groundwater potential of 855 million cubic meters (excluding Sikkim). The Central Groundwater Board has assessed the replenishable groundwater potential as 265.5 million cubic meters. All the hilly regions have low groundwater potential, the lowest being in Sikkim. Most of the surface water in this zone is in a highly dynamic state due to its high gradient and only a very small quantity of freshwater percolates to the ground. There is considerable scope for exploiting groundwater in the Barak valley, the Manipur valley, and other isolated pockets of the plains. By and large, the groundwater of the Northeastern Region is of a quality suitable for irrigation.

3.10 Flood problems

The immense surface waters of the Northeast causes extensive flood damage and drainage problems as the rivers descend from hilly regions into the plains, particularly in the Assam valley of the Brahmaputra basin, the Cachar valley in the Barak basin, and in the lower reaches of the Teesta River in south Sikkim and the adjoining North Bengal region. The average annual flood damage is in the order of Rs. 1,720 million (see appendix 5), despite an extensive network of embankments, river training works, drainage channels, and other infrastructure on all the rivers of the region. Recurring uncontrolled flooding was among the factors motivating the government to establish the Brahmaputra Board in 1972 with the mandate to prepare priority master plans and to implement projects for the control of floods in the Brahmaputra and Barak valleys. Under the mandate, the Brahmaputra Board has investigated several storage projects with multipurpose benefits for hydropower, flood control, and irrigation on the major north bank tributaries of the Brahmaputra and Barak. Specific flood cushion provision was built into all the major schemes planned for the Subansiri and Siang rivers and at Tipaimukh on the Barak. The first two of these projects have undergone major changes in conceptualization, as described in section 6 below.

3.11 Irrigable area

The Northeastern Region has a total irrigable area of 3.2 million hectares, of which only 0.95 million hectares is irrigated. It is estimated that at the current pace of development, the irrigation potential could reach full development by 2050.

4. Hydropower potential and status of development

The immense hydro potential of the Northeast is well known. The first comprehensive study carried out during 1953–1959 by the then Central Water and Power Commission's Power Wing (reconstituted as the Central Electricity Authority) estimated the economically exploitable hydro potential of the Brahmaputra basin at 13,400 megawatts at 60 percent load factor, which constituted about 32 percent of the country's hydropower potential of 42,100 megawatts at 60 percent load factor.

Reassessment studies were carried out by the Central Electricity Authority during 1978–1987 taking into account further detailed topographic and hydrological data, advances in design and construction technology, and emerging trends in energy costs. This study placed the hydropower potential of the country at 84,040 megawatts at 60 percent load factor from a total of 845 projects, which would yield energy of 442 billion kilowatt-hours per year. With seasonal energy, the total energy potential is assessed to be 600 billion kilowatt-hours per year. The hydropower potential of the major river basins of the country, according to the two studies, is shown in table 3 and figure 7. Distribution of hydropower potential by power region (1978–1987 study) is shown in figure 8.

Table 3. Assessments of hydropower potential of major basins (tabular)

Basin	Potential megawatts at 60% load factor		No. of identified schemes: Reassessment study (1978–87)
	First survey (1953–59)	Reassessment study (1978–87)	
Indus	6,583	19,988	180
Ganga	4,817	10,715	226
Central Indian	4,300	2,740	142
West-flowing	4,350	6,149	63
East-flowing	8,633	9,532	84
Brahmaputra	13,417	34,920	140
Totals	**42,100**	**84,044**	**845**

Figure 7. Assessments of hydropower potential of major basins (graphic)

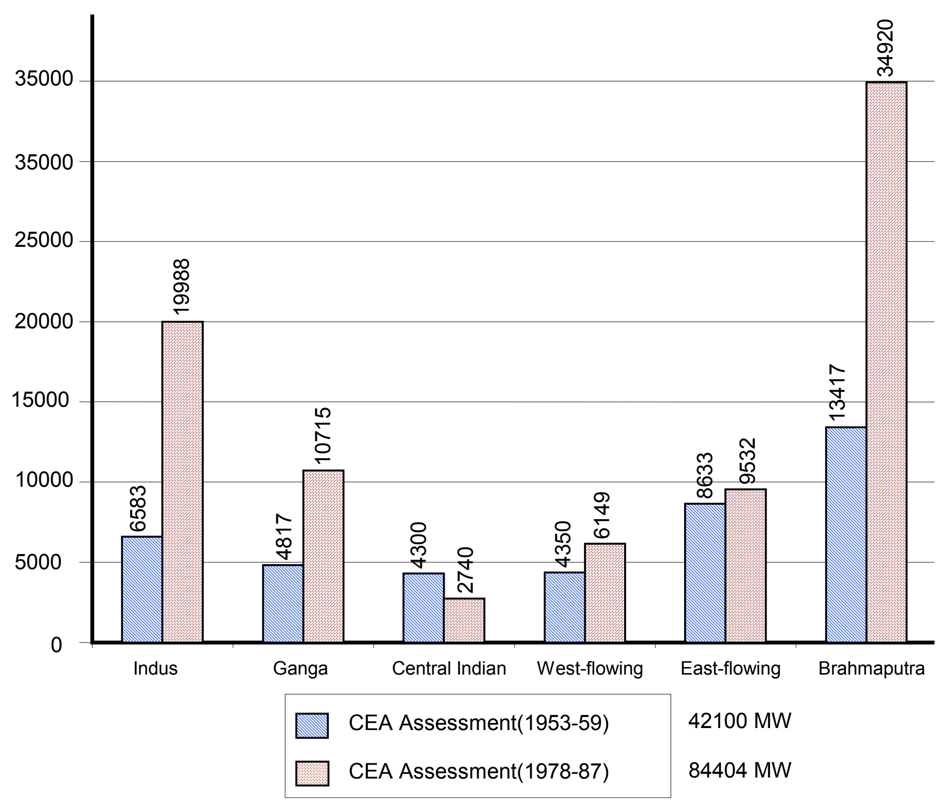
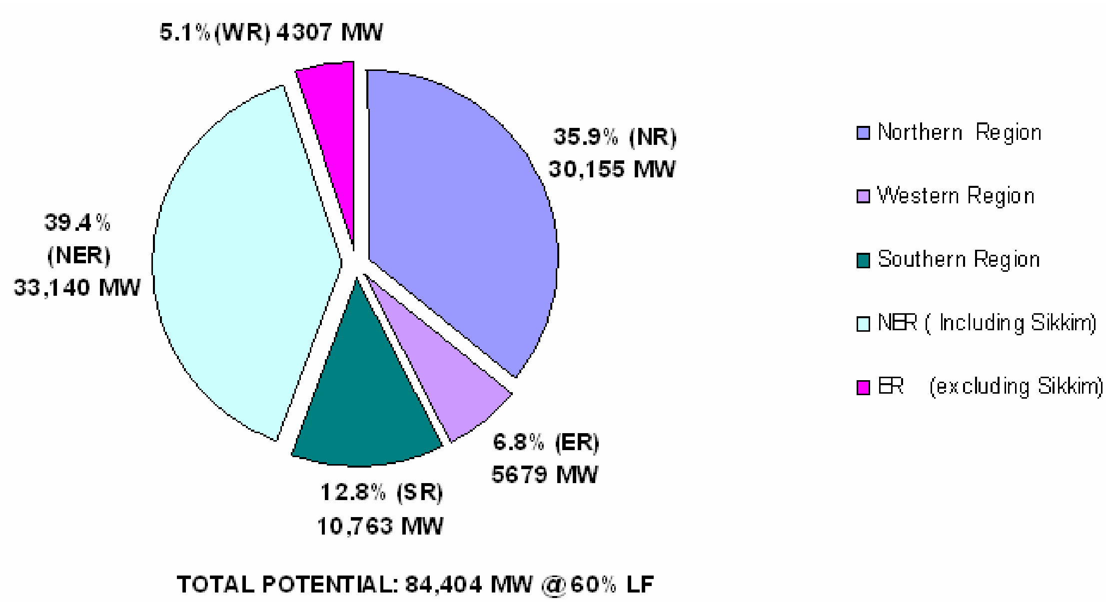


Figure 8. Distribution of hydropower potential by power region



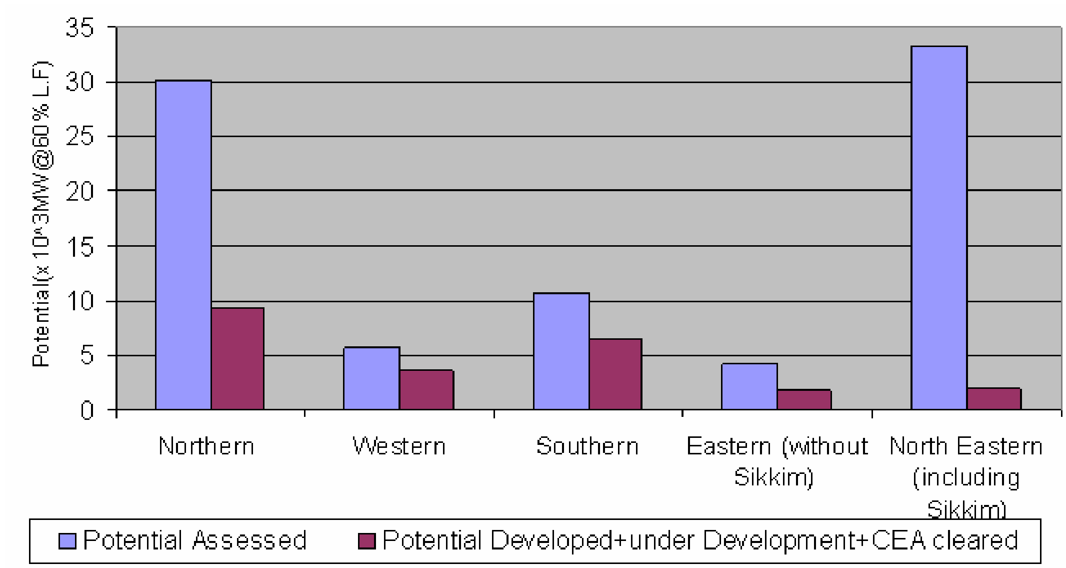
About 75 percent of the potential of the country comes from the Himalayan river systems (the Indus, Ganga, and Brahmaputra) and is located in the Northeastern (39.4 percent) and Northern (35.9 percent) power regions. The hydropower potential of the Northeastern power region, including Sikkim, is 33,100 megawatts at 60 percent load factor, almost all of which excluding Sikkim is from the Brahmaputra basin.

Hydropower development in the early plan periods gained momentum as a number of major river valley projects with power generation as a major component were taken up. Until the mid-1970s, hydro capacity constituted more than 40 percent of the total installed capacity. However, with the emergence of widespread power shortages in the country during the 1970s coupled with delays in completion of some of the hydro projects, there was a shift towards development of thermal power generation to meet the power shortages. This has led to a decline in the rate of hydro capacity addition, and the hydro capacity of 30,935 megawatts (March 2005) now constitutes only 26 percent of the total capacity in the country. With this installed capacity only 18.91 percent of the estimated hydro potential is exploited and 81.09 percent is available for development. Appendices 6 and 6A show the status of exploitation of hydro potential by region and in the states of the Northeast. The status of hydropower potential development by region (with the Sikkim potential included in the Northeastern power region) is depicted in figure 9.

The potential developed so far in the Northeastern power region (including the state of Sikkim) is only 1.72 percent, which is much less than the 18.91 percent developed in the country as a whole. Even after completion of the hydro schemes under construction, the potential exploited in the region would be 4.84 percent, compared to 24.13 percent with completion at the national level. The potential development including the schemes cleared by the Central Electricity Authority would be 6.05 percent in the Northeastern power region and 27.74 percent in the country as a whole. The regional level of hydro potential development (including schemes cleared by the Central Electricity Authority) is expected to be 31 percent in Northern, 63.71 percent in Western, 61.26 percent in Southern, and 40.5 percent in Eastern power regions.

Though the unexploited hydro potential (69 percent) in the Northern power region is substantial, the emerging power supply situation indicates that it may be adequate only for meeting the growing power demands within the region. The tentative 11th Power Plan (2007–2012) proposes addition of 13,886 megawatts of hydro capacity in the region, which is more than 50 percent of the total hydro addition in the country during the plan period. Even with this large hydro capacity addition, the Northern power region would be a net importer of power at the end of the 11th Power Plan period. Considering this growing power demand in the Northern region there may be little if any surplus for export to other regions.

Figure 9. Status of hydro potential development by region



The total hydropower potential available in Western, Southern, and part of Eastern (excluding Sikkim) power regions is relatively limited, constituting about 25 percent of the potential in the country. The potential exploited in these regions is also relatively high, at 64, 62, and 41 percent respectively. Further, the hydro potential of these regions is from peninsular rivers, which have more than 80 percent of their flows during the monsoon, requiring construction of storage reservoirs for economic hydropower generation. The development of the potential of these river systems is constrained by submergence, environmental, and interstate issues (as with projects in Karnataka and Tamil Nadu, Indravati basin, Western Ghats). There is also concern about the impact of an adverse hydro-thermal mix on the power system in the country, particularly in the Western and Eastern power regions, and also to some extent in the Southern region, where hydro development has slowed down. It is a recognized fact that the operational flexibility and economics of generation of hydro stations make them best suited to peaking power. The hydro development scenario in the Western, Southern, and Eastern power region systems indicates that the future peaking needs of these regions would have to be substantially met from sources outside the region. Lack of complementary peaking capacity in these systems could lead to suboptimal utilization of large base load thermal capacities in these regions. In this context, development of the large unexploited hydro potential in the Northeastern power region assumes importance and urgency.

5. Emerging hydropower development and the Northeastern Region

During 2001, to give further impetus to the efforts for the development of hydropower potential, the Central Electricity Authority undertook a preliminary ranking study of the yet to be developed sites. The study analyzed 399 out of the 845 identified sites (excluding schemes under operation or construction or cleared, and small hydro schemes less than 25 megawatts) to determine the priority for development of schemes identified in the reassessment studies. This was followed by the 50,000 megawatt hydroelectric initiative, launched by the prime minister of India in May 2003 as part of the Mission 2012: Power for All plan. Under this initiative, preliminary feasibility reports for 162 hydroelectric schemes (spread across 16 states) selected on the basis of a preliminary ranking study, were prepared. The preliminary feasibility reports covered conceptual layouts and planning of the project works, hydrological studies, power potential assessment, determination of installed capacity, cost estimates, environmental aspects (including rehabilitation and resettlement aspects), power evacuation system, and tariff computation. The regional distribution of the schemes is summarized in table 4.

Table 4. Preliminary feasibility reports: Regional distribution of hydro schemes

Region	Number of schemes	Installed capacity (megawatts)
Northern	61	11,285
Western	17	1,464
Southern	8	2,107
Eastern	4	1,189
Northeastern	72	31,925
All India	**162**	**47,970**

The 31,925-megawatt capacity of the Northeastern power region schemes constituted about 67 percent of the total capacity emerging from the study. The distribution of the schemes by state is shown in table 5.

Table 5. Preliminary feasibility reports: distribution of hydro schemes by NE state

State	Number of schemes	Installed capacity (megawatts)
Arunachal Pradesh	42	27,293
Meghalaya	11	931
Mizoram	3	1,500
Nagaland	3	370
Sikkim	10	1,469

The preliminary feasibility reports indicated that 78 schemes (out of 162 schemes) with an installed capacity of 34,020 megawatts have an economic first-year tariff of less than Rs. 2.50 per kilowatt-hour. The levelized tariff in all the cases is less than Rs. 2.00 per kilowatt-hour. Table 6 shows an analysis of the tariffs applicable to schemes in the different power regions. The tariff calculations are made at bus bar accounting for evacuation costs of transmission up to the grid pooling stations. The tariff calculations are done using a debt equity ratio of 70:30, interest at 10 percent, depreciation by straight line method, interest on working capital at 10 percent, and return on equity at 16 percent. The tariff calculations were based on Central Electricity Regulatory Commission tariff notifications prevalent at that time.

Table 6. Preliminary feasibility reports: Breakdown of regional schemes by tariff

	Tariff < Rs. 2.50		Tariff Rs. 2.50–3.00		Tariff Rs. 3.00–3.50		Tariff > Rs. 3.50	
Region	**No. of schemes**	**Installed capacity (MW)**	**No. of schemes**	**Installed capacity (MW)**	**No. of schemes**	**Installed capacity (MW)**	**No. of schemes**	**Installed capacity (MW)**
Northern	44	9,134	8	1,337	2	252	7	562
Western	. .	. .	. .	. .	. .	. .	17	1,464
Southern	4	1,600	. .	. .	2	381	2	126
Eastern	. .	. .	. .	. .	. .	. .	4	1,189
Northeastern	30	23,286	8	945	10	2,368	24	5,326
Total	**78**	**34,020**	**16**	**2,282**	**14**	**3,001**	**54**	**8,667**

. . Zero.

The Northeastern power region has 30 schemes with an installed capacity of 23,286 megawatts in this economic category. About 50 percent of these schemes (16 schemes, 18,366 megawatts) have first-year tariffs less than Rs. 2.00 per kilowatt-hour. The studies also showed that the potential hydro sites in Western, Southern, and Eastern power regions generally have tariffs greater than Rs. 3.50 per kilowatt-hour, and it would be economical to import power from the Northeastern power region, given a margin of R. 1 or more between tariffs. The substantial block of economic hydro potential available in the Northeastern power region would thus merit serious action-oriented consideration to help meet the future power needs of the country in the first quarter of this millennium. Overall, the Northeastern power region has a vital role to play in the future hydropower development of the country.

The draft National Power Plan notified by the Central Electricity Authority in November 2004 covers the proposed 11th Plan (2007–2012) and indicative 12th Plan (2012–2017). The total capacity additions required during these plan periods has been assessed as 61,000 megawatts and 69,500 megawatts. The hydro component of these capacity additions is 22,420 megawatts and 34,500 megawatts, which constitutes about 37 and 50 percent respectively of the proposed capacity additions. As part of this exercise the 11th Plan hydro schemes have been identified, and the regional distribution of proposed capacity addition is shown in table 7.

It may be seen from table 7 that the hydro capacity addition in the Western, Southern, and Eastern regions is only about 10 percent of the total planned under the 11th Plan. This again reflects the previously mentioned difficulty of achieving balanced power development in these regions. The National Power Plan studies also indicate that at the end of the 11th Plan, even with a large hydro program, the Northern power region would be a net importer of power and the overall coal availability in the country for power generation would only be 368 million metric tons compared to the required 469 million metric tons. This hydro resource and power development scenario again indicates the need for early development of the Northeastern Region's hydro potential in order to help meet the future electricity needs of the country.

While large-scale development of the Northeast's hydropower potential finds justification in the context of the overall power demand in the country, it is also essential to consider and identify avenues for utilization of electricity in the region. The long term (2016–2017) projections of power demand in the country (table 8) indicate that regional distribution of demand for power would be more or less at the current levels. The demand for power in the Northeast is expected to be only 2 percent of the total. Even among the states of the Northeastern power region (table 9), Arunachal Pradesh, which has the highest concentration of economic hydroelectric potential, has an estimated peak demand of less than 200 megawatts by 2016–2017. Special efforts are therefore needed to encourage the growth of demand for power in the region. Such an increase in demand would create employment opportunities and economic activity, which would be beneficial to the region. Industrial and agricultural development and total electrification of villages and homes should also form part of this power sector development plan. The subsequent improvement in their personal well-being would enable the inhabitants of the Northeast to view the development of hydro resources as a venture bringing regional benefit, not merely for export and the benefit of others outside the region.

Table 7. Proposed hydropower capacity addition by region

Region	No. of schemes	Installed capacity (MW)	Benefits 2007–2012 (MW)	Spillover to 12th Plan (MW)
Northern	40	13,886	13,886	0
Western	4	540	540	0
Southern	4	670	670	0
Eastern	6	1,029	1,029	0
Northeastern	15	8,385	6,295	2,090
Total (All India)	**69**	**24,510**	**22,420**	**2,090**

Table 8. Long-term electricity forecasts by region

Region	Energy requirement (GWh)			Peak load (MW)		
	2006–07	2011–12	2016–17	2006–07	2011–12	2016–17
Northern	220,820	308,528	429,480	35,540	49,674	69,178
Western	224,927	299,075	395,859	35,223	46,625	61,966
Southern	194,102	262,718	354,599	31,017	42,061	56,883
Eastern	69,467	90,396	117,248	11,990	15,664	20,461
Northeastern	9,501	14,061	20,756	1,875	2,789	4,134
A&N Islands	70	44	111	11	17	26
All India	**719,097**	**975,222**	**1,318,644**	**115,705**	**157,107**	**212,725**

Note: Data for Sikkim are included in Eastern region.

Source: Draft National Electricity Plan, CEA, November 2004.

Table 9. Long-term electricity forecasts by NE state

State	Energy requirement (GWh)			Peak load (MW)		
	2006–07	2011–12	2016–17	2006–07	2011–12	2016–17
Arunachal Pradesh	303	423	588	97	136	189
Assam	5,294	7,604	10,870	991	1,423	2,034
Manipur	1,039	1,672	2,679	252	406	651
Meghalaya	955	1,410	2,071	198	293	430
Mizoram	525	838	1,331	136	217	345
Nagaland	388	555	790	96	141	200
Tripura	997	1,559	2,427	253	396	616
Region without Sikkim	9,501	14,061	20,756	1,875	2,789	4,134
Sikkim	239	312	405	62	61	105
Region with Sikkim	9,740	14,373	21,161	1,937	2,850	4,249

Source: Draft National Electricity Plan, CEA, November 2004.

6. Issues in development of hydropower

6.1 General issues

Hydropower is a renewable and economic energy source, less subject to price fluctuations than energy sources using fossil fuels. Hydro stations can be started and stopped quickly and are able to accommodate system load variations, making them ideally suited for meeting system peak loads. They enable the thermal and nuclear capacities to operate at base load, allowing the overall system to operate more economically and contributing to system reliability. Hydro projects are generally located in hilly and remote areas, and their development can help create such infrastructure as roads, communications, and electricity in these areas. Storage hydro schemes can also provide irrigation, flood control, and navigation benefits. Hydro projects avoid most of the greenhouse gas emissions associated with thermal projects. Presently, small hydro schemes are eligible for carbon trading benefits. There is no difference between small and large hydro projects in the technology of power generation or their basic parameters and features, other than size and installed capacity.

There are however a number of concerns in the development of hydropower, and the development effectiveness of large dams has been a topic of international discussion in recent decades. In response to growing opposition to large dams, the World Commission on Dams (WCD) reviewed a number of dam case studies and summarized its findings in a report (WCD 2002). A key conclusion of the report was that while “dams have made an important and significant contribution to human development, and benefits derived from them have been considerable … in too many cases an unacceptable and often unnecessary price has been paid to secure those benefits, especially in social and environmental terms, by people displaced, by communities downstream, by taxpayers and by the natural environment.” The report also observed that a “lack of equity in the distribution of benefits has called into question the value of many dams in meeting water and energy development needs when compared with the alternatives".

The report recommended reviews of ongoing and planned hydropower projects. Each review would aim to:

- Use a stakeholder analysis based on recognizing rights and assessing risks, and identification of a forum of stakeholders that is consulted on all issues affecting them
- Enable vulnerable and disadvantaged stakeholder groups to participate in an informed manner
- Include a distribution analysis of the allocation of costs and benefits of the project
- Develop agreed mitigation and resettlement measures to promote development opportunities and benefit sharing for displaced and adversely affected people
- Avoid, through modified design, any severe and irreversible ecosystem impacts
- Provide for an environmental flow requirement, and mitigate or compensate any unavoidable ecosystem impacts; and design and implement recourse and compliance mechanisms.

Dams impact river ecosystems and the livelihoods and cultural heritage of the populations of river basins. River ecosystems are considerably affected in a number of ways. Dams block rivers and reduce downstream river levels, thus reducing the amount of water in the downstream ecosystem and impeding the passage of nutrients and silt, and fish and other aquatic organisms. Fish habitat is further affected by alterations to the water temperature, oxygen and silt levels, and speed of river flows. As a result fish migration and fish spawning in upstream watercourses are considerably impacted. These impacts can be mitigated to a certain extend by targeted strategies such as fish passages for both upstream and downstream movement, and by maintaining environmental flows downstream of the dam site. Water quality can be controlled by using multilevel offtakes and aerating turbines, by removal of vegetation from the impoundment, and by integrated watershed and erosion management practices in the water catchment area. In some regions, the introduction or excessive proliferation of natural or exotic pest species has resulted in additional adverse biological impacts such as algae blooms. Another negative impact can be increased risk to human health because of higher mosquito populations or an increased uptake of contaminants in the food chain. Therefore, any potential development of hydropower should address these considerations in a strategic environmental assessment that deeply integrates environmental and social considerations in the decisionmaking process, based on, among other things, a comprehensive review of alternatives to hydropower development. During construction and operation of a hydropower plant, all activities and impacts should be monitored and executed according to an environmental management system agreed upon by the various stakeholders in the region.

WCD estimated that between 40 and 80 million people had been displaced from their lands by large dams, at times resulting in economic hardship, disintegration of communities, and loss of the natural resources upon which community livelihoods depended. As a result, the benefits of hydropower development have gone disproportionately to the affluent and rich segments of the population, while the poor have borne many of the costs.

This is one of the feared outcomes of hydro development in the Northeastern Region of India, where hydropower development would mainly take place in the tribal areas in the hills.

Without appropriate consultation and benefit sharing the construction of hydropower schemes is likely to result in physical loss of homes and lands, disruption of community networks and loss of cultural heritage, and a difficult transition to alternative means of earning a livelihood, particularly since the people of the Northeast rely heavily on local land and resources for their way of life and traditional existence.

Therefore, successful development of hydropower should specifically aim to provide affected communities with improved living and public health conditions, with an equitable distribution of benefits of the project through revenue sharing. Local knowledge of communities should be utilized in project planning, construction, and operation, and should incorporate the provision of community infrastructure such as water and electricity systems. The planning process for hydropower development should ensure that adequate consultation is undertaken with community and institutional stakeholders in order to identify the impacts on the community and appropriate mechanisms for impact mitigation and improvement of livelihoods. A comprehensive resettlement plan should have the consent and acceptance of the community, and provide sustainable long-term solutions to protect the livelihoods and social cohesion of the community.

The history of dam construction in India has not been without critics and controversy. Most of the debate is based on anecdotal rather than statistical evidence. Proponents of dams point to the large downstream benefits, while opponents highlight the upstream costs, with each side generalizing from specific cases. The only major statistical assessment of dams is based on a 2005 study conducted at Massachusetts Institute of Technology and Yale University (Duflo and Pande 2005). Controlling for a number of possible statistical biases (for example the low initial poverty levels characteristic of communities in hill districts), the authors found that the results of a survey of mainly irrigation dams in India show that neither the market (through migration) nor the government (through transfers and compensation) are able to compensate the population living in the area of dam construction with benefits equivalent to those derived from the dam by the population living downstream of it. Hence the dams resulted in uncompensated upstream impacts.

All of this suggests that to lower resistance to dam construction there is a need to pay careful attention to the impacts upstream and develop credible and implementable mechanisms for distributing benefits in ways that promote development and growth. If people anticipate that relocation is the precursor to increased poverty they will continue to resist hydropower development, intensifying social and political unrest in the region. Managing these issues is inherently difficult because it requires balancing diffused interests against concentrated interests. And it asks those affected by submergence to trade today’s certainties for tomorrow’s uncertainties. This will require far-reaching changes in institutions in order to mobilize trust, change expectations of impoverishment induced by relocation, and give voice to communities.

6.2 Technical and organizational issues in the Northeastern Region

While hydro projects are relatively trouble free in operation, they involve complexities from concept to completion. Difficult access, remote locations, and lack of infrastructure are the first set of problems, and hamper project investigation in the Northeast. This constraint has to some extent been addressed under the 50,000 megawatt hydroelectric initiative, and there is now a set of reasonably analyzed hydro projects that can be taken up for survey and investigations and preparation of detailed project reports, and this process has commenced in some economic sites.

The next set of major problems in hydropower development involves creation of infrastructure, ensuring adequate investigations to minimize geological surprises, land acquisition, rehabilitation and resettlement of project-affected populations, clearance of forest and other environmental features, and potential law and order problems (as exist in many parts of the Northeast).

The hydropower potential assessment of the Northeastern power region (34,900 megawatts at 60 percent load factor) is based on major storage developments in the Siang or Dihang (the main stem of Brahmaputra), Subansiri, Lohit, and Dibang river basins. In the studies carried out during the 1980s large storage-based hydro projects with flood benefits had been investigated in the Subansiri, Siang (Dihang), and Barak basins. These projects had substantially higher firm power benefits (compared to run-of-the-river developments) with the ability to meet system demand variations (seasonal as well as diurnal) and to provide substantial benefits of flood control in the Assam valley. These projects have however been shelved on account of problems associated with submergence and the reluctance of the Government of Arunachal Pradesh to permit their implementation. These projects have been redesigned as cascades of dams to minimize submergence. Availability of regulating or flood control storage at the upper dam sites is presently under investigation and study. The lower Subansiri project (8 units x 250 megawatts = 2,000 megawatts), the lowermost site in the Subansiri basin – at the same site of the earlier high dam investigated by the Brahmaputra Board – has been taken up for construction by the National Hydroelectric Power Corporation (NHPC). There is no specific provision for flood control but the reservoir (live capacity 427 million cubic meters) would be kept at minimum draw-down level during the monsoon period to provide some flood moderation benefit. It would be filled up to full reservoir level towards the end of the monsoon and then depleted to minimum draw-down level in a regulated manner in the interest of power generation. The middle Subansiri (8 x 200 = 1,600 megawatts) and upper Subansiri (8 x 250 = 2,000 megawatts) are under investigation but the progress of the survey is constrained by the recent Supreme Court order barring construction of any storage scheme upstream of the lower Subansiri hydroelectric project, which is under construction. The developments in the Dihang basin have also undergone modifications as cascade development.

The Himalayan rivers exhibit characteristic flow patterns, recording their minimum flows during the winter months (December to February). With the onset of summer and snowmelt, river flows gradually increase to attain their maximum values during the monsoon months (June to September). These variations in flow could create problems for run-of-the-river schemes, including the difficulty of absorbing the large block of base power during the monsoon months. In contrast, power from storage projects can be adjusted to suit system demand during the day, from day to day, and from high-flow seasons to low-flow seasons, equivalent to having a gas turbine generator in the system to meet system demand as and when needed but with no fuel cost. The present Central Electricity Regulatory Commission tariff notification does not, however, offer any specific incentives for power from storage projects, despite the well-recognized system benefits. The storage projects are in essence treated on the same footing as diurnal pondage projects. Under the present shortage conditions and widespread demand control measures it has been possible to absorb seasonal power from run-of-the-river plants. However, a large number of such plants would, while increasing the energy availability during the monsoon months, pose serious problems of low energy availability during winter months. On the other hand, availability of regulating storage would even out the output variations and enable greater flexibility in operation to suit system demand and optimize the operation of base load thermal stations. In addition to maximizing power benefits, storage schemes would also provide flood control, irrigation, and navigation benefits. These advantages of storage hydro need to be given adequate attention by the Regulatory Commission and factored into the determination of tariffs.

There are some recent developments that have called into question the realizability of storage projects in the Northeast. In its order on a writ petition filed in respect of the lower Subansiri project under construction by NHPC, the Supreme Court has ruled that there should be no construction of dams upstream of the project in future. The Government of Arunachal Pradesh has also conveyed its decision that the projects in the state should be developed as run-of-the-river schemes and storage schemes should be avoided as far as possible. However, construction of storage dams is essential for maximizing the benefits. There are no doubt issues of uneven distribution of benefits and costs, sharing the cost of flood moderation, and rehabilitation of project-affected populations. A policy on resettlement and rehabilitation specifically tailored to the socioeconomic and cultural milieu of the Northeast would facilitate progress and is of some urgency.

Under Section 8 of the Electricity Act (2003), before giving concurrence to a proposed hydro scheme the Central Electricity Authority is to satisfy itself that the scheme does not "prejudice the prospects for the best ultimate utilization of the river or its tributaries and the ultimate development of the river or its tributaries for power generation consistent with the requirements of drinking water, irrigation, navigation, flood control and other public purposes". Thus the Central Electricity Authority would have a crucial role in guiding the development of the river basins for optimization of benefits. There is no other act or law that can prevail over the decisions of individual states in these matters. Only through a consultative and political process can a national and regional consensus evolve. The concurrence requirement of the Central Electricity Authority for hydro projects has also been strengthened by a notification by the central government under Section 8(1) of the Electricity Act fixing the capital cost norm for hydro projects that require reference to the Central Electricity Authority for concurrence. With allocation of hydro projects to the private sector, this regulatory measure requires attention. Presently, only central sector projects are referred to the authority for investment sanction.

7. International issues

Most river systems of the Northeast are transboundary, and in some cases follow national borders. The countries involved are India, China (Tibet), Bhutan, Bangladesh, and Myanmar.

7.1 China (Tibet)

The Brahmaputra River originates in Tibet as the Tsangpo, flows into India as the Siang (or Dihang), and empties into the Bay of Bengal after traversing Bangladesh. Some of the tributaries of the Brahmaputra also have catchment areas in Tibet. There are no proposals for the basin involving submergence beyond Indian territory. Diversion and consumptive use of the waters in Tibet would have an impact, particularly on postmonsoon flows in the basin. There is no specific information on any such proposals except for occasional media speculation (box 3).

There are possibilities for utilizing the U-bend (called the "Big Bend") in the Tsango River (Brahmaputra) between Tibet (China) and Arunachal Pradesh in India for large-scale hydropower development. A drop of about 3,000 meters is available where the Tsangpo flows at an altitude of 3,600 meters and descends to Gelling in Arunachal Pradesh, which could be utilized for generation of a very large amount of power. This possibility has been identified in studies but has not been mooted so far between the two countries for initiating any feasibility study.

Box 3. Media speculation on upstream development of the Brahmaputra

In an article entitled "Diverting the Brahmaputra: Declaration of War", posted on the rediff.com website and quoting a 17 July 2003 article published in the People's Daily, it stated that: "China plans to conduct a feasibility study in October on the construction of a major hydropower project on the Yarlung Zangbo River in the Tibet Autonomous Region. An expert team [was sent] to the area for preliminary work between late June and early July."

Source: http://www.rediff.com/news/2003/oct/27spec.htm.

The issues between the two countries in the development of the Brahmaputra and other transboundary rivers are yet to be conceptualized and would have to be discussed between the governments for resolution in a spirit of cooperation for mutual benefit and satisfactory utilization of the waters of the river system.

7.2 Bhutan

The river systems (the Pagladiya, Manas, Sankosh, Rydak, and Torsa) of Bhutan join the Brahmaputra from the north in Indian territory. There is excellent ongoing cooperation between the two countries regarding water resource development for hydropower generation. The Jaldhaka project (2 megawatts) in West Bengal, India, was implemented under agreement between the two countries as long ago as 1961. Two hydro projects in Bhutan – the Chukha project (336 megawatts) and the Kurichu project (45 megawatts) – have been implemented with Indian assistance. Surplus power from these projects is exported to India. The revenue to Bhutan from the sale of power to India was Rs. 2,170 million during 2004–2005 (at a tariff of Rs. 1.50 per kilowatt-hour). There will be a large increase in this revenue when the Tala hydro project (1,020 megawatts) becomes operational in 2006–2007. Bhutan has also identified a number of potential hydropower projects, out of its total identified potential of 30,000 megawatts, that require a fairly solid measure of regional investment. Surveys and investigations, with Indian assistance, are also in progress for the Punatsangchu project (870 megawatts), which is identified for more export of power to India. India is thus the single largest investing country in the power sector in Bhutan, which is now contributing to about 45 percent of the country's gross revenue. Bhutan perceives its power development as contributing to the gross national happiness – GNH – of its people, a multidimensional measure that Bhutan has adopted as a novel addition to the more commonly used gross domestic product (GDP) in the national planning process.

Proposals for the construction of storage dams in Bhutan on the Manas and Sankosh rivers have been studied in the past. These projects when implemented could provide flood control and irrigation benefits in addition to a large amount of hydropower, though the environmental and submergence issues of the two projects need further detailed study. These and other projects in Bhutan could be developed for the mutual economic benefit of the two countries.

7.3 Myanmar

The Kolodyne River of Mizoram and Manipur flows into Myanmar. Under a memorandum of understanding signed between India and Myanmar, NHPC has completed investigations on the 800-megawatt Tamanthi hydro project in Myanmar. The power from the project would be mainly for export to India. The cooperation on this project augurs well for the development of the potential of the border and transboundary rivers between the two countries.

7.4 Bangladesh

The run-of-the-river type developments on the Brahmaputra and its tributaries in India would have no impact on water availability downstream. The storage developments in the Brahmaputra basin would have beneficial impacts of reduced flood damage and augmentation of dry-season flows for possible irrigation and navigation benefits in both countries.

The Tipaimukh multipurpose project on the Barak, proposed at the trijunction of Manipur, Mizoram, and Assam, seems to have raised ill-founded apprehension in Bangladesh that the project would dry up the Barak River and cause summer flooding in the Sylhet bowl. This project, with a specific flood cushion, would provide substantial flood relief to flood-prone areas in the Cachar valley in India and the Sylhet region in Bangladesh. The proposed Fulertal barrage, about 100 kilometers downstream of the Tipaimukh dam, would regulate the tail water releases from the Tipaimukh power plant for limited irrigation in India, and the balance releases would not cause any winter flooding in Bangladesh. In fact, Tipaimukh was the first flood moderation study suggested by Bangladesh after the Indo-Bangladesh Joint Rivers Commission was established in 1972. The joint declaration of the prime ministers of India and Bangladesh in Dacca on March 1972 (box 4), on the establishment of the commission, is pertinent to a balanced understanding of this issue.

Box 4. Joint declaration on founding of Joint Rivers Commission (March 1972)

"To strengthen economic and developmental cooperation the two Prime Ministers decide:

To establish a Joint Rivers Commission comprising experts of both countries on a permanent basis to carry out a comprehensive survey of the river systems shared by the two countries, formulate projects concerning both the countries in the fields of flood control and to implement them.

Experts of the two countries are directed to formulate detailed proposals on advance warnings, flood forecasting, study of flood control and irrigation projects on the major river systems and examine the feasibility of linking the power grids of Bangladesh with adjoining areas of India, so that the water resources of the region can be utilized on an equitable basis for the mutual benefit of the peoples of the two countries."

Source: Press release of Government of India, March 1972.

The development of the Northeast's hydro potential would also provide an opportunity to Bangladesh to avail hydro peaking support for its grid and would facilitate linking the power grids of Bangladesh and India, to the benefit of both countries.

8. Flood control in the Brahmaputra basin

8.1 Flood control component of projects

Despite recurrent flood problems in the Brahmaputra and Barak basins, the only multipurpose project that is under construction with flood control as a specifically identified benefit is the Pagladiya multipurpose project. The project involves construction of an earthen dam of about 26 meters height and 23 kilometers length on the Pagladiya (a tributary of the Brahmaputra) in Nalbari District, Assam, and envisages irrigation benefits to 54,000 hectares, flood moderation in 40,000 hectares, and incidental power generation of 3 megawatts. The original approved estimated cost of the project was Rs. 4,792.1 million at 1995 price levels. The cost allocation amongst the distinct and assigned objectives of power, irrigation, and flood control was based on the bearability concept. The benefit of flood control from the specific flood cushion was estimated as the avoided annual flood damage downstream, and the cost allocation to flood control was estimated using a benefit:cost ratio of unity.

There are no hydropower or multipurpose schemes in the Barak basin planned and approved with a specific flood mitigation component except for the Tipaimukh hydroelectric project (box 5). Though Rs. 2,870 million (estimated cost of the project is Rs. 51,638 million, December 2002 price levels) was estimated as the cost allocable to flood control, the project is being considered as a power project with full cost chargeable to power. Box 6 shows the principles used in cost allocation.

In the lower Subansiri project, which is under construction as a run-of-the-river scheme, the reservoir will be kept at a lower level during the monsoon months for flood absorption and no cost allocation has been made for flood mitigation.

Assessment of the flood moderation benefits in the Brahmaputra basin of the large storage projects on the Subansiri and Dihang (Siang) was carried out during the 1980s when plans for the schemes were formulated. The flood benefits of the cascade alternative are being assessed but would be substantially lower than for the large storage projects, as the regulating storage would be lower. The major storage dams planned on the Dibang and Lohit rivers can provide substantial flood benefits in the Brahmaputra valley in Assam. An integrated study of the river system with the planned storages would be necessary, and an expert group set up by the Ministry of Water Resources is examining this aspect, though the situation regarding flood benefits is uncertain, particularly in view of the Supreme Court orders on the lower Subansiri project and the decision of the Government of Arunachal Pradesh on storage projects.

Box 5. Tipaimukh multipurpose project

Tipaimukh dam on the Barak, proposed for construction at the trijunction of Assam, Mizoram, and Manipur, is a162.8-meter-high rockfill dam to provide a live storage capacity of 8,325 million cubic meters (and flood moderation storage of 875 million cubic meters above this storage) and a dam site power station with an installed capacity of 6 units of 250 megawatts capacity each. The project would afford a firm power generation of 401 megawatts continuously and an annual energy generation of 3,516 gigawatt-hours. For flood absorption and moderation, 2.5 meters depth of storage (875 million cubic meters) below the full reservoir level has been earmarked. The submergence area is about 27,500 hectares involving properties in 90 villages in Manipur and 10 in Mizoram.

The cost allocation to flood was calculated using the bearability concept. The annual flood benefit downstream in the Cachar, Karimganj, and Hailakandi districts of Assam (in an area of 0.15 million hectares) is assessed as Rs. 256.9 million. The cost allocable to flood control was assessed at Rs. 2,870 million in the total estimated cost of Rs. 30,516.7 million (1995 price levels).

The implementation of the project has been entrusted to the North Eastern Electric Power Corporation (NEEPCO). The power component of the project was accorded technoeconomic clearance by the Central Electricity Authority for an estimated cost of Rs. 51,639 million at December 2002 price levels. The cost allocable to flood control has been kept at Rs. 2,870 million (at the same level as in the 1995 estimate). The issues pertaining to sharing of the cost of allocation to flood control by the beneficiary states and sharing the cost of diversion of the national highway (coming under submergence) and for security aspects are yet to be decided.

Sources: Detailed project report of Tipaimukh hydroelectric project, Brahmaputra Board, July 2003

8.2 Cost allocation to various uses

Flood control in the Brahmaputra basin is plagued with uncertainties with regard to storage projects, and the issues relating to the sharing of the costs of flood control remain unresolved. Apart from the matters of the beneficiary states' ability or inability, or reluctance, to meet the flood control costs, the uneven distribution of costs and benefits (for example submergence in one state and benefits and flood control in another state), and the resettlement and rehabilitation issues arising from submergence, are the main issues requiring policy direction. Several options could be considered, bearing in mind past practices in this regard:

- The central government to bear the flood control component of the project as a social benefit
- Evolve resettlement and rehabilitation measures specifically tailored to the socioeconomic and cultural milieu of the region
- Reduce the interest rate on capital investment by 1 percent or as required to cover the cost of the flood control component
- Increase the income tax exemption limit on the power revenues from the present 10 years to 15 years
- Increase the free power to the home states from 12 percent to any other appropriate percentage to compensate for the additional submergence and for the loss of power due to the exclusive flood cushion

- Create a revolving grant fund (supported by the central government) for flood control and storage projects
- Access funds from international institutions for this component as a grant for social uplift of the affected region
- In whichever valley of a state flood control benefits are provided, proportionate cuts could be effected on the annual allocations made to the state under the Finance Commission's recommendations for the relevant period for flood relief (Centre contributes 75 percent and state 25 percent). In the case of Assam, the entire flood-affected Cachar valley would have relief from floods (of 1 in 100 year flood frequency) when the Tipaimukh dam is completed. Hence, the allocations for flood relief to the state could be curtailed in proportion to the losses suffered on an annual average basis.

Box 6. Principles of cost allocation

The principles of allocation costs between various benefits are laid down in the Indian Standards in IS 7560-1974, which prescribes the following basic principles:

"The cost allocated to a purpose should be

- Not more than the benefits to be achieved by that purpose
- Not more than the cost of an alternative project built for that purpose alone
- Not less than the cost of the items meant for the specific (exclusive) use of that purpose.

Besides the above three basic principles, due consideration should be given to the national priority or urgency of any purpose over others at the time of formulation of the project or subsequent review."

While hydropower benefits and costs can be exactly calculated, for assessing flood control benefits the alternatives are difficult to evaluate. Alternative measures other than construction of the dam include construction of embankments and cut channels. These measures substituted for storage in reservoirs are short term and involve recurrent annual maintenance charges. The benefit streams from these measures have different timescales and hence apportionment of cost by this method is difficult. The alternative of building a storage reservoir exclusively for flood control is generally not justifiable. Overall, application of the bearability concept is considered the appropriate method for cost allocation, particularly for flood control. This concept takes into consideration the fact that the cost allocation of the project should be so oriented that the major part of the cost goes to that function of the project that may pay it back without undue strain.

Source: Detailed project report of Tipaimukh project, Brahmaputra Board.

9. Irrigation benefits in hydroelectric projects

The Northeastern Region has a total irrigable area of 2.3 million hectares, of which only 0.95 million hectares is irrigated. It is estimated that at the current pace of development, the irrigation potential could reach full development by 2050. Hydropower projects implemented, under construction, and planned have no direct irrigation component. However, the regulated flows from these projects should enable increased irrigation in the plains of Assam and the Cachar valley, provided reregulating structures are planned near the irrigation command areas.

In the case of the Tipaimukh multipurpose project an irrigation potential of 49,000 hectares has been projected from the storage, provided a reregulating structure is implemented on the Barak River at Fulertal, about 100 kilometers downstream of the Tipaimukh dam.

Based on a comprehensive survey of the distribution of benefits of dams for irrigation in India, Duflo and Pande (2005) argue that the benefits are mainly derived downstream, whereas there is generally no increase in public infrastructure and public goods in the district where the dam is located. Furthermore, their findings indicate that the poverty gap is significantly increased in a district where dams are located, whereas the gap is decreased in downstream districts.

There is a modest but useful unexploited potential for groundwater and minor irrigation development in the hill regions of the Northeast, and far more scope in the Imphal valley and Assam. Large schemes take time but groundwater, river lift, and small diversions offer significant immediate possibilities. Hydropower development could indirectly contribute to this development.

10. Rationale for development of hydropower in Northeastern Region

Exploitation of the large hydro potential in the Northeastern Region would, as explained earlier, contribute significantly to satisfying power demands outside the region and could be the mainstay for meeting future peaking needs in the country. It could also benefit the region itself through the development of infrastructure such as roads, communications, and electricity supply to remote hilly areas, improving the quality of life. However, for the economic development of the Northeast and the benefit of its population, the nexus between energy, industrial growth, and creation of wealth would have to be exploited. This would require a separate study to identify energy-intensive industries that could be set up in the region to utilize the cheap hydropower available. Similarly, industries that could be set up based on local resources should be identified. Further hydropower development in the Northeast should provide the local population with access to electricity comparable to other parts of the country. This would require development of a transmission network within the region and subtransmission and distribution systems within the region's states. In places where it is not feasible to extend the transmission network alternative means of providing electricity through nonconventional sources and mini or micro hydro schemes should be considered as an essential element of regional hydropower strategy, paving the way for acceptance of projects by the stakeholders in the region.

In hydropower projects executed within the central sector and funded by the central government, the home state receives 12 percent of the power generated from the project free of cost. This concept is also being followed by the states for hydro projects allotted to the private sector for execution. The benefit of free power that would be available to the states from hydropower developments could be utilized to extend electricity supply to unserved areas, and the surplus power could be traded to provide additional revenue to the state and enable financing of the social sector on a large scale. The revenue to Arunachal Pradesh from such free hydropower would be substantial. Presently, free power from the Ranganadi project amounts to about 180 gigawatt-hours with revenue potential of Rs. 450 million. The revenue to the state would increase to Rs. 3,760 million on completion of the ongoing Kameng and lower Subansiri projects. From the schemes assessed in the preliminary feasibility reports (section 5) in

Arunachal Pradesh having a tariff of less than Rs. 2.50 per kilowatt-hour, the free power to the state in a year would be about 10,450 gigawatt-hours. The revenue from the sale of this energy to the state at Rs. 2.50 per kilowatt-hour would be Rs. 26,125 million per year (run-of-the-river and storage schemes; see appendix 7) compared to the state's total estimated revenue receipts of Rs. 14,078 million during 2004–2005.

While there would be benefits of revenue to the states and the spin-off advantage of hydropower development in remote areas, it is necessary to carry out a study of the long-term and short-term impacts of large-scale hydropower development, enabling allocation of costs for mitigation measures in the estimated cost of the projects. Such studies are to be taken up at the time of project investigation and preparation of detailed project reports. The general impacts of hydropower development on environment, forest, ecology, and socioeconomic aspects during the construction and operation phases are well identified and the applicable guidelines are well defined. The impacts of run-of-the-river development are generally not significant and are manageable. However, in the case of storage development there would be a significant impact on the local population affected by submergence. This can be best addressed by evolving a policy on resettlement and rehabilitation specifically tailored to the socioeconomic and cultural milieu of the Northeastern Region. The proposed developments in the Brahmaputra basin have no adverse impact in the countries sharing the basin (see section 7).

Apart from direct costs covered under the project, revenue from the free power could be utilized by the state for poverty alleviation through, for example, village development schemes, infrastructure improvements and extensions, improved education and health care, rural electrification (all villages and households), forest preservation and development, and industrial development.

11. Projects for implementation in Northeastern Region

The Draft National Power Plan (covering the 11th Plan period 2007–2012) notified by the Central Electricity Authority proposes a total hydro capacity of 22,420 megawatts. This program includes 11 hydro schemes in the Northeast with a total installed capacity of 8,385 megawatts to provide 6,295 megawatts of benefits during the 11th Plan period. This capacity addition is about 28 percent of the program for the 11th Plan and is indicative of the thrust towards development of the potential of the Northeast. The region's hydro program includes benefits from five new schemes (1,925 megawatts) in the Kameng basin identified in the studies for the preliminary feasibility reports. These schemes have been taken up for investigation and preparation of detailed project reports.

The hydro capacity addition during the 12th Plan (2012–2017) has been indicated in the National Power Plan as 34,500 megawatts. The schemes to provide this capacity addition are to yet to be identified. However, considering the hydro resource distribution and status of development in the country, a large portion of this capacity has to necessarily come from schemes in the Northeastern Region.

In the competitive environment brought about by the new Electricity Act (2003) (box 7 and appendix 11), attractive and economic tariffs to consumers would be a basic consideration when taking up hydro projects for implementation. In the case of schemes in the Northeast, the cost of power at the delivery point in the receiving state or regional grid would have to be considered. The power-consuming centers are located far away and would require construction of long transmission lines at considerable cost. This is a common problem for utilization of northeastern hydropower and the issues involved are discussed later in this report. It is interesting to note that many private sector entrepreneurs have already embarked on the development of major hydro schemes in Arunachal Pradesh, which in the present power supply scenario would be mainly for use outside the region, and the power market does not perceive transmission of power as a major constraint.

Box 7. Electricity Act, 2003

The Electricity Act of 2003 is a comprehensive piece of legislation replacing the Electricity Act of 1910, the Electricity Supply Act of 1948, and the Electricity Regulatory Commission Act of 1998. The objectives are to introduce competition, protect consumers' interests, and provide power for all. The act provides for a national electricity policy, rural electrification, open access in transmission, phased open access in distribution, mandatory state electricity regulatory commissions, license-free generation and distribution, power trading, mandatory metering, and stringent penalties for theft of electricity, thus ensuring a trajectory of sound commercial growth and enabling the states and the Centre to move in harmony and coordination.

Source: Government of India Gazette Notification, 2003.

12. Approach to selection of schemes for implementation

The studies for the preliminary feasibility reports identified 30 schemes with a total capacity of 23,286 megawatts in the Northeastern Region with a first-year tariff less than Rs. 2.50 per kilowatt-hour (in all cases the levelized tariff would be much less, as may be seen in appendix 7) that can be taken up for detailed investigation and considered for progressive implementation. Given that the power trading in the country is currently taking place at this tariff and even higher for peak power, it would be a reasonable cutoff point for making a beginning regarding further action on hydropower development in the region. It would also give a reasonably large shelf of schemes, which would offer wider choice at the implementation stage. The bouquet of schemes with a tariff less than Rs. 2.50 per kilowatt-hour includes schemes in Meghalaya (seven, totaling 651 megawatts) and Sikkim (four, totaling 835 megawatts). The potential in other northeastern states is limited and tariffs are higher. Meghalaya is developing its hydro potential through state agencies, basically to meet internal demand and export any surplus through the trading route. Sikkim is following a policy for hydropower development through private sector entrepreneurs. Seventeen schemes (16 schemes to the private sector and one to NHPC) in the Teesta basin with a total capacity of about 3,900 megawatts (including schemes investigated earlier and other identified schemes) have already been allocated. The schemes in these two states have therefore not been considered in this analysis. The potential for development would thus be essentially in Arunachal Pradesh. The distribution by basin of this potential and estimated cost is shown in table 10. Further details of the 19 schemes are given in appendix 7.

Table 10. Distribution of hydro potential in basins of Arunachal Pradesh

Basin	No. of schemes	Installed capacity (Mw)	Annual energy (GWh)	Estimated cost (Rs. billion)
Kameng	7	3,000	11,120	95
Subansiri	4	3,500	15,270	150
Siang	3	2,200	11,080	77
Dibang	2	4,500	18,320	168
Lohit	3	8,600	31,330	240
Total	**19**	**21,800**	**87,120**	**730**

Detailed investigations and studies are essential for successful implementation of hydro projects. Infrastructure inadequacies, difficult access to the sites, and law and order problems are issues that constrain investigations and early implementation of projects. Investigation of projects can also be delayed by legal issues, as in the Subansiri case. Reluctance to consider storage projects and changes in state government decisions on implementing agencies are also issues that need resolution. Keeping these aspects in view the following strategy for the development of the Northeast's hydro potential could be considered:

- Initially, run-of-the-river schemes that have least submergence and environmental problems and do not preclude future consideration of storage schemes are to be given priority for implementation. This approach is necessary bearing in mind the need for further study to ensure an integrated approach to the development of water resources to optimize multipurpose benefits.
- Storage schemes that have multipurpose benefits, particularly flood benefits to the lower Assam valley, should not be shelved or converted into run-of-the-river schemes, since benefits once reduced are an irrecoverable loss. A policy on issues concerning storage projects and run-of-the-river measures should be evolved immediately.
- Storage schemes that will deliver both power and multipurpose benefits should be investigated fully and integrated flood control studies of all the storage reservoirs planned on the tributaries of the Brahmaputra should be carried out as an essential basis for any policy decisions.
- A program for investigations and preparation of detailed project reports should be drawn up.
- Schemes with least problems of road access should be implemented first.
- As the schemes for implementation are large in number and size, participation of established public sector organizations operating in the power sector would be required.
- Private sector interest and participation in hydropower development in some states, for example Sikkim, Uttaranchal, and Himachal Pradesh, is a recent positive development. Such involvement of the private sector in schemes in the Northeast would accelerate progress towards implementation.

Based on the above approach, the possible development scenario for the schemes planned for each basin is discussed in the following paragraphs.

12.1 Kameng

Of the seven schemes in the Kameng basin, five schemes (capacity 2,780 megawatts, benefits 1,940 megawatts) are identified in the National Power Plan for benefits during the period of the 11th Plan. This river basin, located at the western end of Arunachal Pradesh, is relatively nearer to the load centers and to the infrastructure available and being built for the ongoing Kameng hydroelectric project, favoring the inclusion of these projects for early implementation. This program is however ambitious considering that the detailed survey and investigations of the projects are yet to be done. Bhareli I (1,120 megawatts) and Bhareli II (600 megawatts), being close to the Kameng hydroelectric project, are accessible and can be commissioned during the period of the 11th Plan, though special efforts would be required to expedite investigations and sanction the investment. The Kameng storage dam project (600 megawatts) located upstream, which would provide regulated discharges to Bhareli I and II projects, could be taken up for benefits during the 12th Plan. Other smaller schemes in the basin could also be considered for benefits during the 12th Plan period.

12.2 Subansiri

Four schemes in the Subansiri basin have very attractive first-year tariffs of less than Rs. 2.50 per kilowatt-hour. Of these, Oju I (700 megawatts) and Oju II (1,000 megawatts) are presently inaccessible and require construction of 60 kilometers of road. The other two projects – Naba (1,000 megawatts) and Niare (800 megawatts) – are connected by single lane road to National Highway (NH) 52. These projects could be considered for benefits during the 12th Plan with investigations and preparation of a detailed project report completed early during the 11th Plan. The construction of these projects would dovetail with completion of the lower Subansiri project during the 11th Plan. An important constraint in this basin is the ban imposed by the Supreme Court on construction of dams upstream of the lower Subansiri. A resolution of this issue is essential for all future developments in this basin. Oju I and II projects could be targeted for benefits during the 13th Plan in continuation of the Niare and Naba.

12.3 Siang

The middle Siang project (1,000 megawatts) has been investigated and the estimated levelized tariff is more than Rs. 3.00 per kilowatt-hour. Investigations have been ongoing for the upper Siang project (11,000 megawatts) and its alternatives. Area of submergence, storage volume, and other project features are yet to be finalized. Considering the importance of storage and the controversy related to building storage dams, it is desirable to postpone these developments to the 13th Plan or beyond. By this time the issues of storage dams could possibly be resolved. The two schemes in the basin featured in preliminary feasibility reports, namely Naying (1,000 megawatts) and Tato II (700 megawatts), which have tariffs less than Rs. 2.00 per kilowatt-hour, merit preference over projects under investigation in the basin (these schemes have recently been allotted to private developers under independent power producer (IPP) contracts). These schemes could be considered for benefits during the latter part of the 12th Plan. Hirong (500 megawatts), upstream in the basin, could be considered for the 13th Plan.

12.4 Dibang

There are two projects on the Dibang: Etalin (4,000 megawatts) and Attunli (1,000 megawatts), which have first-year tariffs of Rs. 1.70 and Rs. 2.35 per kilowatt-hour respectively. With its lower tariff the Etalin project would merit preference for implementation over Attunli. The Dibang valley has poor accessibility. The dam sites of the Etalin project are approachable, with good road connections, though generally access needs to be improved for expeditious construction of the projects in this valley. For this purpose, a bridge about 4 kilometers long needs to be constructed across the Lohit River. Accordingly, the Etalin project can be considered for partial benefits towards the end of the 12th Plan and completion early in the 13th Plan. With an active start on Etalin and improved access to the valley, the Dibang multipurpose project (3,000 megawatts) presently under investigation and Attunli can be considered for benefits in the 13th Plan and beyond.

12.5 Lohit

Demwe (3,000 megawatts), Kalai (2,600 megawatts), and Hutong (3,000 megawatts) are storage projects and would have flood benefits. These projects with a very attractive tariff of less than Rs. 2.00 per kilowatt-hour should be taken up after the policy on storage projects and resettlement and rehabilitation measures is properly developed. This would apply to the Mampani storage project (3,000 megawatts) presently under investigation in the lower reaches of the basin. Assuming that the policy issues are resolved during the 11th Plan period, the schemes in the Lohit basin can be considered for partial benefits during the 13th Plan and beyond.

Tentative phasing of benefits and associated fund requirements by plan are presented in table 11 and in appendix 8.

Table 11. Benefits and fund requirements by plan

Plan period	Benefits (megawatts)	Fund requirement (Rs. million)
11th Plan (2007–12)	1,720	107,642
12th Plan (2012–17)	5,780	251,784
13th Plan (2017–22)	7,700	257,149
14th Plan (2022–27)	6,600	112,475

In addition to the above, schemes in Sikkim could contribute about an additional 4,100 megawatts (annual energy 17,093 gigawatt-hours, estimated cost Rs.183,495 million) by the end of the 12th Plan through private sector and pubic sector participation. A list of these schemes (4 preliminary feasibility report schemes and 14 other identified schemes in the Teesta basin) with estimated costs and annual energy benefits is given in appendix 9. All the schemes except one preliminary feasibility report scheme (Lachen, 210 megawatts) have been allotted for development. In Meghalaya state, the seven schemes identified in the preliminary feasibility report studies are likely to be implemented by the state government. These schemes, listed in appendix 10, would add an additional 651 megawatts (annual energy 2,302 gigawatt-hours) by the end of the 13th Plan at an estimated cost of Rs. 25,231 million.

13. Northeastern hydropower projects and transmission issues

The power from hydro projects in the Northeastern Region would be in excess of the demand in the region and would have to be exported for utilization in other regions of the country. Under the Electricity Act (2003), A central transmission utility has been charged with the responsibility for planning, coordination, and development of interstate transmission systems from the generating stations to the load centers. This function is to be discharged in coordination with the central and state governments, the Central Electricity Authority, generating companies, state transmission utilities, and licensees. The Power Grid Corporation of India Ltd. has since been notified as the central transmission utility by the Government of India under the Electricity Act, and will thus have the responsibility of evacuation of power from hydropower schemes in the Northeast to the identified load centers. The Central Electricity Authority has also produced the National Transmission Plan (July 2005) covering the transmission system required for dispersal of power to the various load centers.

Evacuation of power from the large hydroelectric schemes would involve building long-distance high-capacity transmission lines to other power-consuming regions at considerable cost. Apart from the cost, the transmission lines out of the Northeastern Region have to pass through the Siliguri corridor, a narrow land corridor about 22 kilometers wide and 18 kilometers in length, popularly referred to as the Chicken's Neck. The power from neighboring countries (Bhutan and Myanmar) has also to pass through this narrow corridor. There is therefore a physical constraint that necessitates judicious utilization of the land corridor while conserving the right of way. For evacuation of 25–35 gigawatts of power, the corridor required for transmission lines would be about 800 to 1,200 meters. Corridor availability would not pose any serious constraint in the medium term, and would become less problematic with the possible future development of a grid with neighboring countries.

The main issue in the utilization of northeastern hydropower is the cost of transmission of power to the load centers. Apart from the right of way constraints, the expected future projects in the various river basins of the region would require building transmission lines with greater margins than initially required, which would mean higher transmission costs in the initial years till new projects come on line. This is reflected in the estimated cost of associated transmission systems of northeastern hydro projects planned for commissioning during the 11th Plan. The associated transmission system for evacuation of Kameng (600 megawatt) power is estimated at Rs. 11,000 million, about 50 percent of the cost of the generation project. Similarly, in the case of the lower Subansiri (2,000 megawatts), the transmission cost would be about Rs. 100 billion. In the case of the Tipaimukh project also the transmission cost would be very high and is expected to add about Rs. 1.40 per kilowatt-hour to the cost of power at power station bus bars. The delays in the commissioning of generation projects, which is not uncommon for hydro projects, could worsen the problem. In fact the present regional transmission cost is pegged at a low level on account of such a situation and the inability of states to meet the transmission costs fully.

The attractive generation costs of northeastern hydro schemes are countered to a large extent by the high transmission costs involved for evacuation and intervening transmission systems. Though the initial estimated cost of generation is very attractive at Rs. 2.00 (or less) per kilowatt-hour in some cases, the cost could be higher at completion in view of the uncertainties involved in hydro projects in the Himalayas. There is therefore a necessity to explore avenues to reduce the cost of transmission. This could be done by accessing low-cost long-term loans, financial engineering through back-loaded tariffs, and adopting pooling of transmission costs for the country as a whole. These would require a separate study.

There is at present no problem in the availability of transmission systems beyond the Northeastern power region for dispersal of power as the five power regions of the country are in the process of greater integration within a national grid. The interregional transmission capacity has reached a level of 9,450 megawatts and enabled energy exchange of 12 billion kilowatt-hours among the regions during 2004–2005. This needs to be addressed as more development takes place in the Northeastern power region and bulk power becomes available for consumption in other regions. The interregional power transfer capacity is through asynchronous direct current links, synchronous alternating current links, and radial interstate links at 220 and 132 kilovolts. The interregional transfer capacity is expected to increase to 16,450 megawatts by the end of the 10th Plan (March 2007). The National Transmission Plan corresponding to the National Power Plan proposes to more than double the interregional transfer capability to 37,150 megawatts by the end of the 11th Plan (March 2012).

It is to be appreciated that the interstate transmission system has a shorter lead time than the hydroelectric schemes. The long-term transmission plan could thus be refined as clarity on generation expansion and the consuming centers emerges in the course of future national power plans.

14. Institutional and organizational structures for implementation

Power development is a concurrent subject and water resources is a state subject under the Indian Constitution. The central government has, however, powers to legislate on regulation and development of interstate rivers.

There are a number of organizations at the Centre and state levels working in the areas of power and water resource development in the Northeastern Region. The organizations can be broadly categorized as statutary, policy, and regulating authorities and implementing agencies.

In the water resource sector the organizations involved at the central level are the Ministry of Development of North Eastern Region (MoDONER), Ministry of Power, Ministry of Water Resources, North Eastern Council, Central Electricity Authority, Central Water Commission, and Brahmaputra Board. These organizations and agencies of the Centre are involved in policy formulation, regulation, coordination, and development of the water resource and power sectors in the Northeastern Region.

In the power sector the project-executing agencies at the central level are the North Eastern Electric Power Corporation (NEEPCO), the National Hydroelectric Power Corporation (NHPC), and the Power Grid Corporation. Recently, the National Thermal Power Corporation has entered the northeastern power sector by taking up investigation of hydro projects in the Lohit basin. It is to be noted that central sector organizations play a predominant role in the power sector of the Northeast, with about 76 percent of present hydro capacity and 50 percent of the total capacity owned and operated by central public sector undertakings.

At the state level the organizations dealing with these matters are state electricity boards in Assam and Meghalaya (undergoing restructuring in accordance with the Electricity Act, 2003), state electricity departments in all the other six states of the region operating in the power sector, and state irrigation and water resource departments in the water resource sector. In respect of hydropower, Meghalaya and Assam have executed projects in the past and have a few projects under construction in the state sector. The power departments in the other states are involved mainly in transmission and distribution of power and in implementation of small hydro projects. The existing organizations in the state sector in the region by and large are neither equipped nor geared up for taking up major projects. This is evident from the fact that the installed capacity in the state sector in the six states is only 350 megawatts out of the total capacity of 2,419 megawatts in the Northeastern Region (see appendix 3B). In Arunachal Pradesh, which has the highest hydropower potential, the installed capacity in the state sector is only 45 megawatts (hydro 29.5 megawatts). Considering the states' needs, the organization within the six states should be strengthened to undertake transmission and distribution development as a priority. Meghalaya, which is contemplating hydropower development in the state sector, has to consider strengthening the project implementation agency and committing further funds to hydropower development, perhaps by exploring joint sector or private sector participation for increasing the tempo of hydropower development in the state.

The only project in the state sector is the 100-megawatt Karbi-Langpi hydro project of the Assam State Electricity Board. The development of the large hydro potential of the Northeastern Region has therefore to be based on the existing organizations already operating in the region.

It is important to ensure integrated development of projects in the Brahmaputra basin for multipurpose benefits and coordinated operation. The Brahmaputra Board was set up under the Brahmaputra Board Act (1980) to carry out surveys and investigations in the Brahmaputra valley and prepare a master plan for control of floods and bank erosion. In preparing the master plan, development and utilization of the water resources of the Brahmaputra valley for irrigation, hydropower, navigation, and other beneficial purposes was also to be given consideration. The Brahmaputra Board's fulfillment of its mandate has been hampered over the years by a lack of engineering and scientific human resources. Though the board was empowered to take up construction, its activities were limited mainly to survey and investigations and preparation of the master plan, and few flood control works were carried out other than construction works on the ongoing Pagladiya dam project. The board did not have any regulatory powers to implement the projects or the master plan and the state governments' approval was necessary in all the matters.

The various impediments in pursuing even the identified projects in the Subansiri basin and the blanket decision of Arunachal Pradesh not to allow building of storage projects can be attributed to the nonavailability of an agreed master plan. Of relevance to this matter is the prime minister's announcement of November 2004 that "The government will consider establishing a cohesive, autonomous, self-contained entity called the Brahmaputra Valley Authority or the North East Water Resources Authority to provide effective flood control, generate electricity, provide irrigation facilities, and develop infrastructure. Given managerial and financial autonomy, equipped with top-class manpower, and backed by Parliamentary sanction, such a body could be the instrument for transforming the region." In view of this and experience so far, creation of a new empowered organization is an urgent necessity for leading northeastern water resource and hydropower development towards fulfillment of its potential.

Whether such an empowered organization should be a regulating authority or should also be empowered to implement and operate projects requires further debate. Considering the magnitude of the task it would be desirable for such an organization to have the authority to decide on the master plan and coordinate development of the various project components and general policy issues, such as infrastructure development, allocation of costs and benefits to the various beneficiaries, resettlement and rehabilitation, land acquisition and afforestation requirements arising from project implementation, accessing funds, and operation of projects after construction. The implementation of the schemes should be a distinct activity and it is desirable to separate it from the regulatory and superintending functions. The decisions of such an authority in all matters under its purview should be binding on all the agencies involved in planning, development, construction, and operation of plants in the basin to ensure the objectives enunciated by the prime minister. If project implementation was to be carried out in addition to policy-related matters, it would be desirable for this to be done in virgin basins such as those of the Lohit and Dibang. An organizational setup along the lines of the Damodar Valley Corporation in India or the Tennessee Valley Authority in the United States could be considered. For execution of projects, the existing implementing organizations in the central sector should be sufficient. If augmentation of the agencies were considered necessary, basin-level agencies would be an option. It is also to be kept in view that a number of private sector agencies are showing interest in the hydropower sector in the Northeastern Region.

The storage-type hydro projects require operation in coordination with the use and control of water for other purposes, such as flood control, irrigation, and navigation, and the operation of other hydro and thermal stations in the grid, in order for benefits to be optimized. Presently, regional electricity boards (renamed regional power committees under the Electricity Act, 2003) and regional load dispatch centers coordinate the operational planning of the regional power systems. The Electricity Act also provides for establishing a national load dispatch center for optimum scheduling and dispatch of electricity among the regional load dispatch centers. This would enable coordination of operation of power stations in different regions to meet consumer demand in the desired manner. The operation of storage would be guided by the principles set out by the basin authority referred to above.

15. Conclusions and recommendations

The immense untapped hydropower potential of the Northeastern Region is an economic source of electricity that can contribute significantly to the future power demands of the country and merits priority for implementation. The attendant development and improvement of infrastructure and the increased availability of electricity could trigger economic progress in the region.

The immediate justification for the development of the region's hydro potential is to help meet national power demand through export of power to other regions of the country. There is, however, a need to improve access to electricity from the region by upgrading and strengthening transmission and distribution systems and implementation of microhydel and nonconventional energy sources in remote areas where extension of the transmission network would not be economical.

The cost of power transmission to load centers would be substantial in the initial years, making power more expensive at destination. Access to low-cost long-term funds, back-loading transmission tariffs, and the introduction of a national transmission tariff are possible options for resolving the problem.

The hydro potential of the region can be accessed through a mix of run-of-the-river and storage plants. Implementation of run-of-the-river plants with minimum environmental issues should be considered first.

Storage projects in the Brahmaputra basin would provide higher firm power and regulated and dispatchable energy and also provide multipurpose benefits of flood control, irrigation, and navigation. The major problems requiring solution relate to submergence, resettlement and rehabilitation of displaced populations, and the uneven distribution of costs and benefits. Storage projects should not be converted to run-of-the-river plants without detailed study of the long-term implications.

There is an urgent need to address the cost side of the equation. As long as losses remain largely uncompensated the development of hydropower will remain disruptive, fueling division and protest and thus deterring the investment needed to unleash growth and job creation.

For generating greater acceptability of storage projects among affected populations, a policy on resettlement and rehabilitation specifically tailored to the socioeconomic and cultural milieu of the Northeastern Region has to be evolved. Given the sensitivity of the issues, development of policies on storage projects, sharing of costs and benefits, and resettlement and rehabilitation would ultimately require national-level political input.

For integrated development of the water resources of the Brahmaputra basin for optimum multipurpose benefits a coordination mechanism is essential. The North Eastern Council and the Brahmaputra Board should coordinate activities in this regard with the concerned state and central agencies. For implementation of projects, existing organizations in the public sector should be supported by private sector participation to meet the challenges presented by development of the hydro potential.

An empowered apex organization, with the authority to lay down policies for the funding and construction of the infrastructure needed, should be set up to facilitate development of the water resources of the North Eastern Region for multipurpose benefits. A basin organization along the lines of the Damodar Valley Corporation or the Tennessee Valley Authority could be considered for virgin basins such as the Lohit and Dibang, where developmental activities for project investigations are yet to take off and potential for creation of storage dams for multipurpose benefits exist.

The development of the Northeastern Region’s hydro potential could pave the way for formation of a South Asia regional power grid and foster cooperation among the countries in the region.

Appendix 1. Terms of reference

a. Provide an overview of the hydropower potential in the Northeastern Region of India, tapped and untapped, and compare with the scenario in other regions of India

b. Provide an analysis of the hydropower potential to be developed in the Northeastern Region over the next 10 to 15 years (including possible plants) and compare with the hydropower development planned in other regions of the country

c. Analyze the key elements of the development plan: rationale of plant selection and sequencing of construction, characteristics of power supply relative to demand patterns, whether (and how) operations of the different hydropower plants need to be synchronized

d. Analyze the constraints and risks associated with the development plan: financing, technical (for example power evacuation, geology), political

e. Estimate cost and benefits of the hydropower development plan (including power, flood moderation, and irrigation aspects)

f. Estimate allocation of costs and benefits of hydropower development to the different stakeholders

g. Analyze the institutional arrangements required for ensuring that the hydropower potential is developed and operated in an optimal manner (considering technical, economic, sustainability and other aspects).

Appendix 2. Current power supply position (national and Northeastern Region)

India: Power supply position by region, April 2004 – March 2005								
	Energy				**Peak demand/peak met**			
	Requirement	Availability	Surplus/deficit		Requirement	Availability	Surplus/deficit	
Region	MU	MU	MU	%	MW	MW	MW	%
Northern	175,498	159,358	–16,140	–9.2	26,834	24,125	–2,709	–10.1
Western	204,048	181,010	–23,038	–11.3	31,085	24,128	–6,957	–22.4
Southern	147,672	145,395	–2,277	–1.5	23,075	22,364	–711	–3.1
Eastern	57,036	55,678	–1,358	–2.4	8,816	8,533	–283	–3.2
Northeastern	7,119	6,674	–445	–6.3	1,272	1,128	–144	–11.3
Totals (all India)	**591,373**	**548,115**	**–43,258**	**–7.3**	**87,906**	**77,652**	**–10,254**	**–11.7**

Note: Separate data for Sikkim are not available; the data for Sikkim are included in Eastern Region.

Northeastern Region: Power supply position by state, April 2004 – March 2005								
	Energy				**Peak demand/peak met**			
	Requirement	Availability	Surplus/deficit		Requirement	Availability	Surplus/deficit	
State	MU	MU	MU	%	MW	MW	MW	%
Arunachal Pradesh	158	158	. .	. .	63	62	–1	–1.6
Assam	3,787	3,582	–205	–5.4	659	621	–38	–5.8
Manipur	537	523	–14	–2.6	103	103	. .	. .
Meghalaya	1,374	1,228	–146	–10.6	264	207	–57	–21.6
Mizoram	236	222	–14	–5.9	69	67	–2	–2.9
Nagaland	330	324	–6	–1.8	74	71	–3	–4.1
Tripura	700	641	–59	–8.4	188	159	–29	–15.4
Totals	**7,122**	**6,678**	**–444**	**–6.3**	**1,272**	**1,128**	**–144**	**–11.3**

. . Zero or insignificant.

Source: Monthly Review of Power Sector Performance: Executive summary for March 2005, CEA.

Appendix 3A. National installed capacity by region, 31 March 2005

Region/island	Ownership	Hydro (MW)	Thermal incl. nuclear (MW)	Nonconventional incl. wind (MW)	Total (MW)
Northern	State	6,400.6	11,490.7	6.4	17,897.7
	Private	386.0	. .	382.0	768.0
	Central	3,989.0	9,832.0	. .	13,821.0
Subtotal		**10,775.6**	**21,322.7**	**388.4**	**32,486.7**
Western	State	4,420.1	15,529.5	26.3	19,975.9
	Private	447.0	4,688.2	710.4	5,845.6
	Central	1,000.0	6,512.0	. .	7,512.0
Subtotal		**5,867.1**	**26,729.7**	**736.7**	**33,333.5**
Southern	State	10,629.0	8,317.5	33.9	18,980.4
	Private	43.2	2,894.7	2,642.6	5,580.5
	Central	. .	7,170.0	. .	7,170.0
Subtotal		**10,672.2**	**18,382.2**	**2,676.5**	**31,730.9**
Eastern	State	2,277.5	5,655.6	1.1	7,934.2
	Private	0.0	1,441.5	6.6	1,448.1
	Central	204.0	8,847.5	0.0	9,051.5
Subtotal		**2,481.5**	**15,944.6**	**7.7**	**18,433.8**
Northeastern (excluding Sikkim)	State	273.9	823.7	. .	1,097.6
	Private	. .	24.5	1.5	26.0
	Central	860.0	375.0	. .	1,235.0
Subtotal		**1,133.9**	**1,223.2**	**1.5**	**2,358.6**
Islands	State	5.2	50.0	. .	55.2
	Private	. .	20.0	0.2	20.2
	Central	. .	. .	. .	. .
Subtotal		**5.2**	**70.0**	**0.2**	**75.4**
All India	State	24,006.3	41,867.0	67.7	65,941.0
	Private	876.2	9,068.9	3,743.3	13,688.4
	Central	6,053.0	32,736.5	0.0	38,789.5
Totals (all India)		**30,935.5**	**83,672.4**	**3,811.0**	**118,418.9**
Northeast (excluding Sikkim)		**1,133.9**	**1,223.2**	**1.5**	**2,358.6**
Northeast (including Sikkim)		**1,175.3**	**1,242.6**	**1.5**	**2,419.4**

. . Zero or insignificant.

Appendix 3B. Northeastern Region: Installed capacity by state, 31 March 2005

State	Ownership	Hydro (MW)	Thermal incl. nuclear (MW)	Nonconventional incl. wind (MW)	Total (MW)
Assam	State	2.0	595.2	. .	
	Private	. .	24.5	0.1	
	Central	344.8	178.0	. .	
Subtotal		**346.8**	**797.7**	**0.1**	**1,144.6**
Arunachal Pradesh	State	29.5	15.9	. .	
	Private	. .	. .	0.2	
	Central	96.0	21.0	. .	
Subtotal		**125.5**	**36.9**	**0.2**	**162.6**
Meghalaya	State	186.7	2.0	. .	
	Private	. .	. .	. .	
	Central	71.1	26.1	. .	
Subtotal		**257.8**	**28.1**	**. .**	**285.9**
Tripura	State	16.0	111.3	. .	
	Private	. .	. .	1.0	
	Central	60.1	33.0	. .	
Subtotal		**76.1**	**144.3**	**1.0**	**221.4**
Manipur	State	3.2	45.4	. .	
	Private	. .	. .	. .	
	Central	79.4	26.1	. .	
Subtotal		**82.6**	**71.5**	**. .**	**154.1**
Nagaland	State	28.2	2.0	. .	
	Private	. .	. .	. .	
	Central	52.1	19.0	. .	
Subtotal		**80.3**	**21.0**	**. .**	**101.3**
Mizoram	State	8.3	51.9	. .	
	Private	. .	. .	0.2	
	Central	33.00	16.1	. .	
Subtotal		**41.3**	**68.0**	**0.2**	**109.5**
Central unallocated		**123.5**	**55.7**	**. .**	**179.2**
Sikkim	State	32.9	5.0	. .	
	Private	. .	. .	. .	
	Central	8.5	14.4	. .	
Subtotal		**41.4**	**19.4**	**. .**	**60.8**
Totals Northeastern Region		**1,175.3**	**1,242.6**	**1.5**	**2,419.4**

Source of appendices 3A and 3B: Monthly Review of Power Sector Performance: Executive Summary for March 2005, CEA.

[. . Zero or insignificant.]

Appendix 4A. Energy generation, losses, and consumption patterns by region

	Northern Region	Western Region	Southern Region	Eastern Region	Northeastern Region	All India
	GWh (unless otherwise specified)					
Energy generated	157,086	161,528	129,865	70,253	6,569	525,301
Energy purchased	2,008	10,179	9,462	2,809	67	
Total energy available	159,094	171,707	139,327	73,062	6,636	
Energy sales outside region	1,424	175	791	12,091	374	
Energy losses in T&D + unaccounted[a]	59,626	56,567	31,080	24,198	2,564	17,035
% energy losses	37.5	32.9	22.3	33.1	38.6	32.5
Energy sale to consumers	98,045	114,965	107,456	36,773	3,698	360,937
Domestic	29,786.56	22,495.43	26,163.61	9,960.60	1,329.49	89,735.78
%	30.38	19.57	24.35	27.09	35.95	24.86
Commercial	9,597.35	7,812.78	7,266.43	3,190.11	334.83	28,201.49
%	9.79	6.8	6.76	8.68	9.05	7.81
Industrial	26,273.10	45,055.54	34,643.81	17,401.84	1,199.33	12,457.08
%	26.80	39.19	32.24	47.32	32.43	34.51
Agriculture	21,529.52	31,171.45	32,128.49	2,129.51	130.28	87,089.25
%	21.96	27.11	29.90	5.79	3.52	24.13
Others	10,858.59	8,429.61	7,253.54	4,091.19	704.25	143,512.02
%	11.07	7.33	6.75	11.12	19.05	8.69
Consumption in nonutilities	11,116.63	20,752.95	12,075.76	12,438.58	1,013.01	57,396.94
Per capita consumption[b] (kWh)	302.54	477.27	466.81	154.99	92.05	336.51
Number of villages	193,577	130,421	71,128	153,363	38,769	587,252
Villages electrified	148,638	127,760	70,813	118,124	29,696	495,031
% villages electrified	76.8	98.0	99.6	77.0	76.6	84.3

a. T&D = transmission and distribution.

b. Per capita including consumption in nonutilities.

Source: All India Electricity Statistics General Review 2005, CEA.

Appendix 4B. Northeastern Region (including Sikkim): Energy generation, losses, and consumption patterns by state

	Arunachal Pradesh	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Sikkim
	GWh (unless otherwise specified)							
Energy generated (net)	29	827	. .	595	10	24	492	36
Energy purchased	209	2,337	504	372	249	279	343	336
Total energy available to state	238	3,164	504	966	292	303	835	405
Energy sold outside state	. .	. .	. .	8	. .	. .	33	. .
T&D losses + unaccounted[a]	113	1,235	328	167	162	167	388	223
% losses	47.6	39.3	65.2	16.7	55.5	55.0	46.4	55.0
Energy available to consumers in state	125	1,920	175	797	130	136	414	182
Domestic	55	697	104	159	82	77	156	80
%	43.8	36.3	59.1	19.9	63.3	56.4	37.7	43.9
Commercial	10	229	12	31	7	9	36	45
%	7.8	11.9	6.7	3.9	5.4	6.7	8.8	24.5
Industry	2.6	637.1	8.0	455.9	1.7	21.5	72.5	21.4
%	2.1	33.2	4.6	57.2	1.3	15.8	17.5	11.7
Agriculture	. .	50	0.6	0.5	. .	. .	78.7	. .
%	. .	2.6	0.3	0.1	. .	. .	19.0	. .
Others	58	307	51	150	39	29	70	36
%	46.3	16.0	29.3	18.9	30.0	21.0	17.0	19.8
Per capita consumption (kWh)	110	105	71	332	140	65	125	324
Number of villages	3,649	24,685	2,182	5,484	698	1,216	855	447
villages electrified	2,316	19,081	2,084	3,484	695	1,216	820	405
% villages electrified	63.5	77.3	95.5	63.5	99.6	100	95.9	100[b]

. . Zero or insignificant.

a. T&D = transmission and distribution.

b. 42 forest villages not electrified.

Source: All India Electricity Statistics General Review 2005, CEA.

Appendix 5. Northeastern Region: Flood damage by state

(Based on data for the period 1953–2004)

State	Geographic area (ha)	Area liable to floods (million ha)	Maximum area affected any one year during 1953–2004 (million ha)	Area benefited up to March 2002 (million ha)	Av. annual damage to crops, houses and utilities (Rs. million)
Arunachal Pradesh	8.37	. .	0.03	. .	473.2
Assam	7.84	3.15	3.82	1.64	881.4
Manipur	2.23	0.08	0.08	0.13	36.2
Meghalaya	2.24	0.02	0.09	0.01	121.3
Mizoram	2.11	. .	Negligible	. .	38.9
Nagaland	1.66	. .	0.01	. .	27.0
Sikkim	0.71	. .	0.02	0.01	66.9
Tripura	1.05	0.33	0.33	0.03	84.3
Total Northeast	**26.22**	**3.58**	**4.96**	**1.75**	**1,729.2**
Total India		**33.52**[a]	**. .**	**16.43**	**13,477.2**[b]

. . Zero or insignificant.

a. Protectable area assessed by RBA is 34 million ha.

b. Average damage for the period 1953–2004.

Source: CWC Statistics of Flood Damages in the Country, 2005.

Appendix 6A. Status of hydroelectric potential and development by region, 1 July 2005

Region	Potential assessed at 60% load factor	Potential developed at 60% load factor		Potential under development		Potential developed + under development	CEA-cleared schemes potential, 60% load factor		Potential developed + under development + CEA-cleared schemes	
	MW	MW	%	MW	%	%	MW	%	MW	%
Northern	30,155	5,150.0	17.1	2,621.7	8.7	26.7	1,576.7	5.2	9,348.5	31.0
Western	5,679	2,936.3	51.7	497.7	8.8	60.5	184.1	3.2	3,618.1	63.7
Southern	10,763	5,923.7	55.0	153.5	1.4	56.5	516.1	4.8	6,593.3	61.26
Eastern	5,590	1,364.3	24.4	201.2	3.6	28.0	612.0	11.0	2,178.2	38.97
Northeastern (excluding Sikkim)	31,857	517.0	1.6	914.6	2.9	4.5	142.5	0.4	1,574.1	4.9
All India	84,044	15,891.3	18.9	4,388.7	5.2	24.1	3,032.2	3.6	23,312.2	27.7
Eastern (without Sikkim)	4,307	1,311.8	30.4	80.1	1.9	32.3	356.0	8.3	1,747.9	40.6
Northeastern (including Sikkim)	33,140	569.5	1.7	1,035.6	3.1	4.8	399.2	1.2	2,004.3	6.0

Source: CEA.

Appendix 6B. Northeastern Region: Status of hydropower potential and development by state, 1 July 2005

State	Potential assessed at 60% load factor	Potential developed at 60% load factor		Potential under development		Potential developed + under development	CEA-cleared schemes potential, 60% load factor		Potential developed + under development + CEA-cleared schemes	
	MW	MW	%	MW	%	%	MW	%	MW	%
Meghalaya	1,070	121.7	11.4	23.6	2.2	13.6	. .	. .	145.3	13.6
Tripura	9	7.5	83.3	. .	. .	83.3	. .	. .	7.5	83.3
Manipur	1,176	71.7	6.1	42.5	3.6	9.7	. .	. .	114.2	9.7
Assam	351	111.7	31.8	74.2	21.1	52.9	. .	. .	185.8	52.9
Nagaland	1,040	81.8	7.9	. .	. .	7.9	. .	. .	81.8	7.9
Arunachal Pradesh	26,756	122.7	0.5	743.5	2.8	3.3	. .	. .	866.2	3.2
Mizoram	1,455	. .	. .	30.8	2.1	2.1	142.5	9.8	173.3	11.9
Sikkim	1,283	52.5	4.1	121.1	9.4	13.5	256.7	20.0	430.2	33.5
Total	33,140	569.9	1.7	1,035.7	3.1	4.8	399.2	1.2	2,004.3	6.0

. . Zero or insignificant.

Source: CEA.

Appendix 7. Arunachal Pradesh: Preliminary feasibility report schemes with tariff less than Rs. 2.50 per kilowatt-hour

SI No.	Basin/scheme	Installed capacity No. X MW	Type of scheme[a]	Rated head (m)	Annual energy (GWh)	Estimated cost Rs. millions	Const. period (years)	First year / levelized tariff (Rs./kWh)	Benefits during
Kameng									
1	Bhareli II	5X120	ROR	51	2,345	16,985	6	1.67/1.34	11th Plan
2	Bhareli I	8X140	ROR	97	4,112	33,725	6	1.85/1.49	11th Plan
3	Kameng Dam	5X120	Storage	65	2,345	22,640	6	2.29/1.83	12th Plan
4	Kapakleyak	4X40	ROR	245	628	4,635	4.5	1.74/1.39	12th Plan
5	Badao	4X30	ROR	154.5	450	4,440	4.5	2.32/1.87	12th Plan
6	Dibbin	2X50	ROR	151.2	335	3,715	4.5	2.23/1.79	12th Plan
7	Talong	3X100	Storage	171.7	915	8,910	5	2.24/1.78	12th Plan
Subansiri									
8	Oju I	4X175	ROR	700	3,292	35,260	7	2.08/1.69	13th Plan
9	Oju II	4X250	ROR	1,000	4,630	34,930	7	1.46/1.19	13th Plan
10	Niare	4X200	ROR	800	3,357	35,000	6	2.02/1.64	12th Plan
11	Naba	4X250	ROR	1,000	3,995	44,000	7	2.14/1.73	12th Plan
Siang									
12	Naying	4X250	ROR	1,000	5,077	30,170	7	1.18/0.96	12th Plan
13	Tato II	4X175	ROR	700	3,466	26,090	5	1.48/1.20	12th Plan
14	Hirong	4X125	ROR	500	2,535	20,730	6	1.62/1.31	12th Plan
Dibang									
15	Etalin	16X250	ROR	14,069.1	16,070	140,690	8	1.70/1.38	12th/13th Plan
16	Attunli	4X125	ROR	2,725.26	2,248	27,250	7.5	2.35/1.91	13th Plan
Lohit									
17	Demwe	12X250	Storage	1.97	10,824	95,400	8.5	1.97/1.53	13th/14th Plan
18	Hutong	12X250	Storage	1.28	9,900	77,920	7	1.28/1.12	13th/14th Plan
19	Kalai	10X260	Storage	1.01	10,609	66,380	7	1.01/0.88	13th/14th Plan

a. ROR = run-of-the-river.

Source: Summary of Preliminary Feasibility Reports, CEA, 2004.

Appendix 8. Preliminary feasibility report schemes with tariff less than Rs. 2.50 per kilowatt-hour: Phasing of benefits and expenditure

Sl No.	Basin/scheme	Installed capacity (No. X MW)	Estimated cost Rs. millions	Const. period (years)	Phasing of benefits (MW)				Phasing of expenditure (Rs. million)			
					11th Plan	12th Plan	13th Plan	14th Plan	11th Plan	12th Plan	13th Plan	14th Plan
Kameng												
1	Bhareli II	5X120	16,985	6	600				16,985			
2	Bhareli I	8X140	33,725	6	1,120				33,725			
3	Kameng Dam	5X120	22,640	6		600			4,528	18,112		
4	Kapakleyak	4X40	4,635	5		160			927	3,708		
5	Badao	4X30	4,440	5		120			888	3,552		
6	Dibbin	2X50	3,715	5		100			743	2,972		
7	Talong	3X100	8,910	5		300			1,782	7,128		
Subansiri												
8	Oju I	4X175	35,260	7			700			8,815	26,445	
9	Oju II	4X250	34,930	7			1,000			8,733	26,198	
10	Niare	4X200	35,000	6		800			8,750	26,250		
11	Naba	4X250	44,000	7		1,000			11,000	33,000		
Siang												
12	Naying	4X250	30,170	7		1,000			7,543	22,628		
13	Tato II	4X175	26,090	5		700			6,523	19,568		
14	Hirong	4X125	20,730	6			500			5,183	15,548	
Dibang												
15	Etalin	16X250	140,690	8		1,000	3,000		14,069	63,311	63,311	
16	Attunli	4X125	27,250	8			500			8,175	19,075	
Lohit												
17	Demwe	12X250	95,400	9			1,000	2,000		9,540	47,700	38,160
18	Hutong	12X250	77,920	7			1,000	2,000		7,792	38,960	31,168
19	Kalai	10X260	66,380	7				2,600		3,319	19,914	43,147
Total			**728,870**		**1,720**	**5,780**	**7,700**	**6,600**	**107,462**	**251,784**	**257,150**	**112,475**

Source: Summary of Preliminary Feasibility Reports, CEA, 2004.

Appendix 9. Hydro schemes in Sikkim

Sl No.	Basin/scheme	Installed capacity (MW)	Type of scheme[a]	Annual energy (GWh)	Estimated cost Rs. million	Const. period (years)	First year/ levelized tariff (Rs./kWh)
PFR schemes[b]							
1	Dikchu	105	ROR	469	5,190	4	2.15/1.74
2	Panan	200	ROR	762	8,460	5	2.15/1.75
3	Lachen	210	ROR	866	10,469	5	2.35/1.90
4	Teesta I	320	ROR	1298	12,066	5	1.80/1.46
Total PFR schemes		835		3,395	36,185		
Other schemes							
5	Teesta II	300	ROR	1,339	13,170	n.a	n.a
6	Teesta III	1,200	ROR	5,116	60,000	6	n.a
7	Teesta IV	495	ROR	2,403	25,000	n.a	n.a
8	Teesta VI	360	ROR	1,794	15,610	n.a	n.a
9	Rangit II	60	ROR	210	2,500	n.a	n.a
10	Rangit IV	100	ROR	430	4,000	n.a	n.a
11	Jorethang loop	96	ROR	430	4,000	n.a	n.a
12	Rolep Rawland	132	ROR			n.a	n.a
13	Chuzachen	100	ROR	404	4,480	n.a	n.a
14	Bhashmey	52	ROR	207	2,800	n.a	n.a
15	Sada Mangder	70	ROR	245	3,000	n.a	n.a
16	Rongni Chu	98	ROR	435	5,000	n.a	n.a
17	Ruket	33	ROR	125	1,250	n.a	n.a
18	Lingza	160	ROR	560	6,500	n.a	n.a
Total other schemes		**3,256**		**13,698**	**147,310**		
Total Sikkim		**4,091**		**17,093**	**183,495**		

n.a. Not applicable

Note: Except for Teesta stage IV and Lachen hydroelectric schemes, all schemes have been allotted to the private sector for development. Teesta stage IV is an NHPC scheme.

a. ROR = run-of-the-river.

b. PFR = preliminary feasibility report.

Source: Summary of Preliminary Feasibility Reports, CEA, 2004, and Sikkim Govt. website.

Appendix 10. Hydro schemes in Meghalaya

Sl No.	Scheme	Installed capacity (MW)	Type of scheme[a]	Annual energy (GWh)	Estimated cost (Rs. million)	First year/ levelized tariff (Rs./kWh)	Construction period (years)
Preliminary feasibility report schemes							
1	Mawhu	120	ROR	483	4,342	1.40/1.23	5
2	Nongkolait	120	ROR	333	3,928	1.85/1.62	5
3	Nongnam	50	ROR	213	2,720	2.44/2.14	5
4	Rangmaw	65	ROR	230	2,684	2.32/202	5
5	Selim	170	Storage	535	6,520	2.0/1.762	5.5
6	Umduna	57	ROR	231	2,267	1.68/1.47	5
7	Umjaut	69	ROR	277	2,770	1.51/1.32	5
Total		**651**		**2,302**	**25,231**		

a. ROR = run-of-the-river.

Source: Summary of Preliminary Feasibility Reports, CEA, 2004.

Appendix 11. The Electricity Act, 2003

The Electricity Act, which came into being on 10 June 2003, envisages an enabling framework conducive to development of the power sector in an open, nondiscriminatory, competitive, market-driven environment, keeping in view the interests of consumers. Generation has been delicensed and trading has been recognized as a distinct activity from transmission. The Electricity Act also provides for specific dispensation for power development in rural areas. More details of the act are given below.

The act consolidates the laws relating to:

- Generation, transmission, distribution, trading, and use of electricity, and generally taking measures conducive to development of the electricity industry
- Promoting competition, protecting the interests of consumers, and supplying electricity to all areas
- Rationalization of electricity tariffs, ensuring transparent policies regarding subsidies
- Promotion of efficient and environmentally benign policies
- Constitution of the Central Electricity Authority
- Regulatory commissions and establishment of an appellate tribunal and related matters.

The act has 18 parts with the following broad descriptions:

Part I deals with all preliminary and relevant definitions.

Part II describes the National Electricity Policy, in which it is stipulated that the central government "shall, from time to time, prepare the National Electricity Policy and tariff policy, in consultation with the state governments and the authority for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or materials, hydro and renewable sources of energy".

Part III concerns generation of electricity, and states that "Any generating company may establish, operate and maintain a generating station without obtaining a license under this act if it complies with the technical standards relating to connectivity with the grid referred to in clause (b) of section 73.

"Notwithstanding anything contained in section 7, any generating company intending to set up a hydro-generating station shall prepare and submit to the authority, for its concurrence, a scheme estimated to involve a capital expenditure exceeding such sum as may be fixed by the central government, from time to time, by notification."

Part IV elaborates on licensing.

Part V concerns transmission of electricity, including interstate transmission and establishment of a national load dispatch center for optimum scheduling and dispatch of electricity among the regional load dispatch centers.

Part VI covers distribution of electricity and provisions with respect to distribution licensees.

Part VII describes tariffs and tariff regulations.

Part VIII is about the work of licenses.

Part IX is about the Central Electricity Authority, including its constitution and functions.

Part X deals with regulatory commissions, including the constitution, powers, and functions of the Central Commission.

Part XI is about the establishment of an appellate tribunal for electricity.

Part XII deals with investigation and enforcement.

Part XIII is about reorganization of the board, including the vesting of property of the board in state government.

Part XIV deals with offences and penalties, including theft of electricity.

Part XV is about special courts and their constitution.

Part XVI deals with dispute resolution and arbitration.

Part XVII is about other provision, including protective clauses related to protection of railways, highways, airports, canals, docks, wharfs and piers, and telegraphic, telephonic, and electronic signaling lines.

Part XVIII deals with miscellaneous matters, including the coordination forum.

Source: Ministry of Power, 2003.

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