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North –East, 'The Power House of India': Prospects and Problems

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Abstract: *North – Eastern region of India is one of the potential Hydro-Power regions of the country. This region consists of eight states; Assam, Arunachal Pradesh, Tripura, Meghalaya, Nagaland, Mizoram, Manipur and Sikkim. India's vision to be a Developed Nation within 2020 (Vision 2020) is very much depended on uninterrupted supply of power and the North-Eastern region would play a vital role on it. North Eastern Region is enriched with huge water resources carried by the Brahmaputra-Barak and Irrawaddy river systems. The surface water resource of the region is near about 652.3 billion cubic meters that shares 34% of country's total water wealth whereas this entire region occupy only 8% of Indian land mass. Hydro potential of this region is 63257M.W, only 1911 megawatts has been harnessed so far which is only 3.02 % of its' hydro potential. Harnessing this huge hydro potential, North-East could become, 'The Power House of India'. This paper explores the history & growth of hydro power projects, present scenario of power generation, consumption and distribution patterns of the North-East India with highlighting the prospects and problems.*

Keywords: *Brahmaputra-Barak River system, Ecological Issues, Hydro Potential, North-East India, Water Dispute,*

I. Introduction

North – Eastern region of India is one of the less developed regions of the country. This region is commonly known as 'Seven Sisters' that consists of the states; Assam, Arunachal Pradesh, Tripura, Meghalaya, Nagaland, Mizoram, Manipur. Nowadays, Sikkim is also considered as the member of North East. So, these states can be celled as **'***Seven Sisters and One Little Brother'*. This region is not only separated in different administrative units but there are several tribes, language, culture and custom that resist them to be united. Ethnic conflicts between different communities and tribal groups are common matter here. Another matter is also common to all the states of North-East i.e. Under Development. But development of the Northeast is now receiving 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. This region is blessed with natural resources and very much enriched with bio-diversity. Due to its strategic location (Gate Way to South East Asia) and scope of healthy economic relationship with neighboring countries, this region could be one of the potential economic regions of India.

Due to remote location and inhospitable physical conditions, the North-Eastern part of the India was untouched to the other parts of the country for a long time. This situation was become worst after the partition of India because all the major road and railway links through East Bengal were cut down. Even today the people of North-East are facing the problem of poor infrastructure. In spite of the inadequate infrastructures, the people of this part of the country are showing the satisfactory socio-economic growth conserving their tradition and cultural heritages. Central Government enlisted several development programs to prevent the poverty and underdevelopment of the region. The Ministry of Development of North-East is the separate ministry of Govt. of India, trying to run such development programs across the region. But due to lack of infrastructure (mainly transportation and electrification) and natural calamity especially flood in Monsoon season are the main obstructions in developmental process. North –Eastern states have enormous Hydro Potentialities. The surface water resource of the region is near to 652.3 billion cubic meters that shares 34% of country's total water wealth [1]. The Brahmaputra-Barak River system which dominates this landmass has the capability to generate huge amount of hydro power not only for this region but also for the rest of the country. With the proper management of this river system, intensity of flood can be controlled. Moreover, with the generation of potential hydroelectricity, the regional development of North East India would be accelerated.

This paper is an analytical approach to the Hydro potentiality of North-Eastern part of India. Both quantitative and qualitative data have been used in this paper. Data have been taken from several reports of Central Electricity Authority of Government India and NHPC, journals and paper related with various issues on

Hydro projects of North-Eastern states. Moreover, oral narratives have been done with several people, thinker and scholars of North East regarding the issue of Hydro power.

II. Geography of North-East India

2.1 Location:

The North- Eastern region of India is located between 275°7' N and 28°23' N latitude, 89 °46' E and 97°25' E longitude and situated to the south of Himalaya. The total area of the Northeastern Region is 26.22 million hectares where total area of India is 329 million hectares [2]. There are total eight states in North-East Assam, Meghalaya, Arunachal Pradesh, Nagaland, Tripura, Manipur, Mizoram and Sikkim. This region shares international borders with China in the north and northeast; with Bhutan, located between the states of Sikkim and Arunachal Pradesh. It also shares boundary with Bangladesh and Myanmar on the south and south- east. Assam and Tripura occupy the plains while the rest of the states are mostly mountainous 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 (in between Nepal and Bangladesh), the Siliguri corridor, is popularly known as the Chicken's Neck [2].

Fig1: The North-Eastern States.

2.2 Physiographic Features

The Northeast region can be physiographically categorized into the Eastern Himalayas, Northeast Hills (Patkai-Naga Hills and Lushai Hills), Plateau of Meghalaya and the Brahmaputra-Barak Valley Plains.

Physiographic Regions	Administrative Area
Eastern Himalaya	Sikkim and Arunachal Pradesh
North East Hill (Patkai-Naga Hills and Lushai Hills)	Manipur, Mizoram and Nagaland
Plateau of Meghalaya	Entire state of Meghalaya.
Brahmaputra and the Barak Valley Plains.	Assam and Tripura.

Table-1 Physiographic Division of North East

2.3 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), are developed as a consequence of the collision and Subsequent subduction between the land masses of India and Eurasia. 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[3].

The Shillong (Meghalaya) massif is the oldest in north -eastern 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 break up 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].

2.4 Climatic Features

The climate of the region varies from subtropical to extreme alpine. In Assam Valleys and plains the annual mean temperature is 23°C [4] and in winter January is the coldest month with recorded lowest temperature 5.5 °C. Summer is Warm and moist in plain with recorded highest Temperature 37°C (Gwathati 23rd March 2010). [5] The Hilly Tract specially Sikkim and Arunachal experience cold teammate to alpine climate where January is the coldest month, temperature remains well below of frizzing temperature., July is hottest month with mild temperature. Heavy fog is a common feature all over the mountain area throughout 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 3,000 millimeters. Cherrapunji (Meghalaya) is one of the wettest places in the world, the average annual rainfall at Cherrapunjee from 1973-2012 (40 years) was 11,859.4 mm (38.90 feet/466.90 inches).[6] In 1974 it had rained 24,555.3 mm (80.56 feet/ 966.74 inches) the highest annual rainfall in any one place in a year. On 16th June 1995, it had rained 1563 mm in 24 hours (5.12 feet) - the highest recorded rainfall received in one place in one day [6].

2.5 River Systems of North-East

The North Eastern Region is enriched with bountiful water resources carried by numerous rivers originating mainly form Trance Himalaya, Middle Himalaya and Sub- Himalaya on the north, Patkai-Purbachal hills on the north east and east side and Karbi-Jaintya-Meghalya-Garo hills on the southern fringe. The Brahmaputra - Barak sub-system of Ganges –Brahmaputra system is dominated over the region. Brahmaputra originates from Angsi or Chema-Yung-Dung glacier in the Kailas range of the Tibetan plateau [7]. It travels near about 1800 km through the Tibetan plateau, Arunachal Pradesh and Assam of India and Bangladesh. In Bangladesh it is known as Yamuna. After joining with the Padma (distributaries of the Ganges) the name of the joint channel is Meghana and then it merges with Bay of Bengal. The Barak has its origin at the Manipur-Nagaland border, passes through the southern part of Assam as a tributary of Brahmaputra it enters to Bangladesh [8]. Third river system of North –East, Irrawaddy has its origins in Myanmar, passes entirely through Myanmar and empties in to Bay of Bengal. Thus all rivers of this region and many of their tributaries are international in character with courses lying in more than one country and their basin shared by many countries.

Fig 2: Ganga- Brahmaputra River system.

Source: http://commons.wikimedia.org/wiki/File:Ganges-Brahmaputra-Meghna_basins.jpg

Individually the basin of Brahmaputra, the Barak and the Irrawaddy occupy 68.42 % (174528 sq km), 16.36% (41723sq km) and 7.27% (18539 sq km) of the region. These three rivers basins together occupy 92.04% (234790 sq km) of the total area of North East India. The joint catchment area of Brahmaputra- Barak claim 84.78% (216251 sq km) of North-East and it is the dominant river system [1]. The surface water resource of the region is near to 652.3 billion cubic meters that shares 34% of country's total water wealth. Whereas this entire region occupy only 8% of land mass of India. Per capita and per hectare availability of water in this region is highest in the country.

III. History, Growth and Prospects of Hydro-Electricity in North-East India

Electricity is a key factor for development and improving the quality of life. Harnessing the potential hydropower of the Northeastern Region we can open the avenue of growth and provide the opportunity of self dependence to the people of this region. This would be their sound contribution to the national economy. In early years after independence, the large hydro potential of this region was unexplored for a various factors,

such as the inhospitable environmental condition, poor grid transmission system, lack of investment in hydro electricity sector, poor accessibility, and low demand of power in the Northeastern Region.

The history of Indian hydro- electricity started with installation of a mini hydro-electricity plant near a tea estate at Sidrapong for the Darjeeling Municipality in 1897 near to this region [9]. Before independence there was no such remarkable hydro-electricity plant in North-Eastern India. After the independence Government of India realized the hydro potentiality of the region. The hydro potential of the Northeast was studied during 1953–1959 by the Central Water and Power Commission's Power Wing [10]. It was estimated that economically exploitable hydro potential of the Brahmaputra basin could be 13,417 megawatts at 60 percent load factor, which constituted about 31.86 % of the country's hydropower potential of 42,100 megawatts at 60percent load factor. Another study was carried out by the Central Electricity Authority during 1978–1987[10]. This study suggested that theoretical hydropower potential of the country would be 148701 M.W and 84,044 megawatts at 60 percent load factor from a total of 845 projects, which would yield energy of 442 billion kilowatt-hours per year [10]. About 75 percent of the hydro potential of India will come from the Himalayan river systems i.e. the Indus - Ganga- Brahmaputra river system and rest 25% from other river systems.

Name of the basin	First survey (1953–59) Potential megawatts at 60% load factor (MW)	Reassessment study (1978–87)		No. of identified schemes: Reassessment study (1978–87)
		Hydro Potential in MW	Potential megawatts at 60% load factor (MW)	
Indus	6583	33832	19988	180
Ganga	4,817	20711	10715	226
Central Indian river system	4300	4152	2740	142
West-flowing rivers	4350	9430	6149	63
East-flowing rivers	8633	1451	9532	84
Brahmaputra	13417	66065	34920	140
Total	42100	148701	84044	845

Table-2Assessments of Hydropower Potential of Major River Basins (1978-1987)
Source: CEA

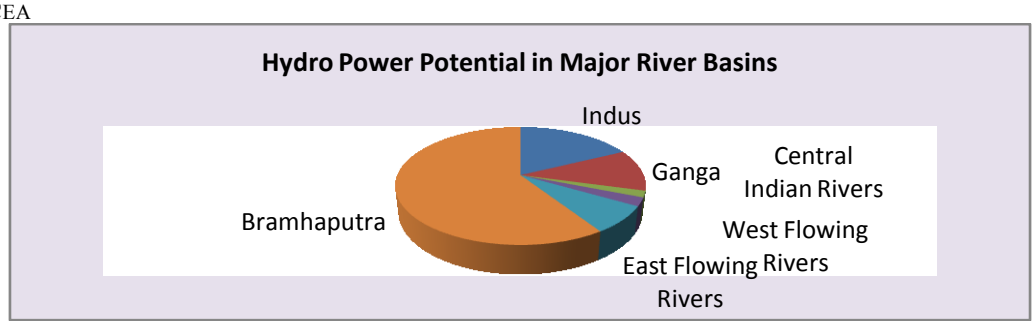

Fig: 3 Hydro Potential of Major River Basins.

In early plan periods, a number of initiatives have been taken to generate hydro power on major rivers. After the mid 70s due to heavy power shortage and emergency demand for industry and modern agriculture, Government of India encouraged the thermal power sectors. This has led to a decline in the hydro power production. The share of hydropower in our country continued declining since 1963. The hydro share declined from 50% in 1963 to about 25% in 2010. [11] Now the Government of India again emphasized on Hydro sector but the progress is not satisfactory at all.

Serial no.	Plan period	Installed Hydro power in MW
1	1st plan (1951-56)	1061
2	2nd plan(1956-61)	1917
3	3rd plan(1961-66)	4124
4	Three Annual Plans (1966-69)	5907
5	4th Plan (1969-74)	6966
6	5th Plan (1974-79)	10833
7	Annual Plan (1979-80)	11384
8	6th Plan (1980-85)	14460
9	7th Plan (1985-90)	18307
10	Two Annual Plans (1990-92)	19194
11	8th Plan (1992-97)	21658
12	9th Plan (1997-02)	26269

13	10th Plan (2002-07)	34654

Table: 3 Development of Hydro Power in Different Plan Periods.
Source: CEA Hydro Development Plan 2012-2017

According to a recent report of CEA on 1.10.2013, 23.53% of, Hydro potential of the country has been harnessed so far that is 35002.8 M.W out of 148701 M.W, well below the desirable optimum level of 40 percent. In this data the pump storage schemes have not been included. However, according to the 2nd Annual Conference on Hydro Power in India conducted by the *Infraline Energy* on April 15-16, 2013 total installed capacity of all types of Hydro plants of the country is 39449 M.W. The achievement of 11th plan is 5544 M.W with all types of the Hydro plants and target for the 12th Plan is 10897 M.W. [12]

Name of the Region	Name of the States and Union Territories	Potential Hydro Power in M.W	Installed Hydro power in M.W	Installed Hydro power in %
North	Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Rajasthan, Delhi, Chandigarh, Uttaranchal, Uttar Pradesh	53395	15643.3	29.29
South	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Pondicherry	16458	9426.9	57.27
East	Orissa, Jharkhand, Bihar, West Bengal.	6663	2469.7	37.06
North-Eastern	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim.	63257	1911	3.02
Western	Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh, Goa.	8928	5552	62.18

Table-4 Power Regions and Their Hydro Power Potential (pump storage scheme excluded). Source: CEA (as on 01.10.2013)
Source: http://www.cea.nic.in/reports/hydro/he_potentialstatus_region.pdf

From the above data it is clear that the North-Eastern region has the maximum Hydro Potential, almost 42.54% of country but achievement is lowest, yet 96.98 % of Hydro potential to be harnessed. It is the one of the promising Hydro potential region of the world and could be 'The Power House of India'.

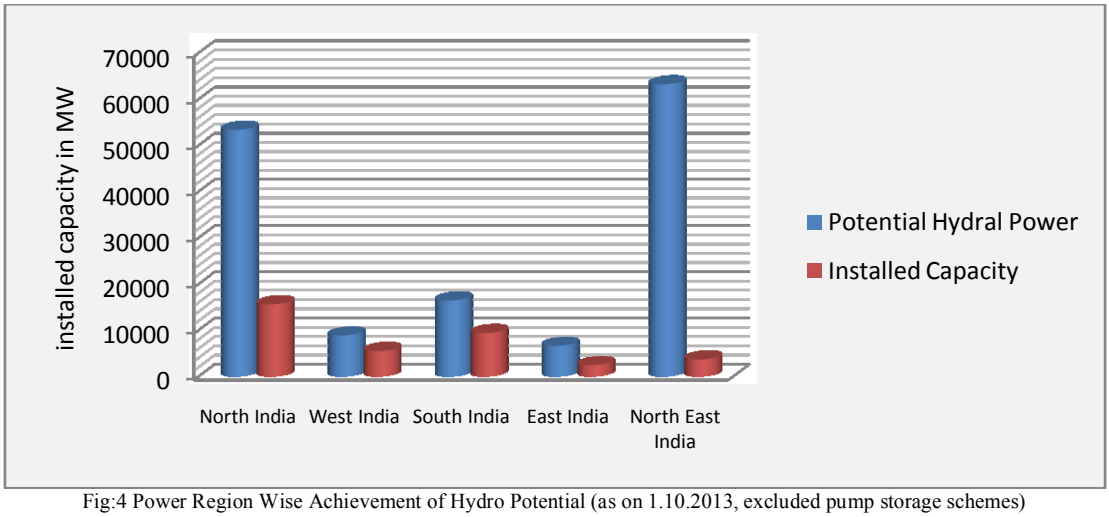

Fig:4 Power Region Wise Achievement of Hydro Potential (as on 1.10.2013, excluded pump storage schemes)
Data Source: Source: http://www.cea.nic.in/reports/hydro/he_potentialstatus_region.pdf

The consumption pattern of electricity in the North-Eastern region is mainly dominated in the domestic and commercial sectors. The industrial consumption is only 1,200 gigawatt/hours which 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 where national average is 390 kilowatt/hours. The rate of village electrification in the North-East 76.6% of the total villages (29,696) is lower than the national average of 84.3%. Nagaland and Sikkim are the two 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) [13].

Due to improvement of bilateral economic relation between India and China and the strategic location (Gate way to South East through Myanmar) the scope of industrialization of North-Eastern region has been increased. This region is also blessed with several natural wealth; according to a recent study of Geological survey of India (GOI) under the Ministry of Mines; the Brahmaputra and Barak valley are enriched with natural oil and gas, Tripura is a major reservoir of natural gas, Manipur has potential deposits of platinum group of elements (PGE) Massive chromite, Meghalaya is enriched with various minerals like phosphates, kaolin and china clay, dolomite, silimanite, carborundum including high class value uranium is found in Domiasait, West

Khasi Hills district, there are also potentialities of iron ore deposits in the northern part of East Garo Hill district. [15] North-East India is also famous for tea, rubber, orange, pine apple, tobacco, bamboo, jute, silk production. FICCI has mentioned that it is one of the potential industrial regions of the country so that the uninterrupted supply of electricity would be the key factor.

Central Electricity Authority has projected the energy requirement for this region in recent future in contest of potential industrial growth as follows;

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	5294	7604	10870	991	1425	2034
Manipur	1039	1672	2679	252	406	651
Meghalaya	955	1410	2071	198	293	430
Mizoram	525	838	1331	136	217	345
Nagaland	388	555	790	96	141	200
Tripura	997	1559	2427	253	396	616
Sikkim	239	312	405	62	61	105

Table-5 Energy Requirements of North-Eastern States
Source: Draft National Electricity Plan, CEA, November 2004

The Northeastern power region (including Sikkim) has achieved only 3.02% of its' hydro potentiality up to October 2013, where as national average is 23.53%. Even after completion of different hydro schemes under construction, the potentiality will be achieved up to 4.84 % only.

Name of the State	Potential Hydro Power in M.W	Capacity Under Operation		Capacity Under Construction		Capacity yet to be Developed	
		MW	%	MW	%	MW	%
Meghalaya	2394	282	11.78	40	1.67	2072	86.54
Tripura	15	0	0	0	0	15	100
Manipur	1784	105	5.89	0	0	1679	94.11
Assam	680	375	55.14	0	0	305	44.85
Nagaland	1574	75	4.76	0	0	1499	95.23
Arunachal Pradesh	50328	405	0.80	2710	5.38	47213	93.82
Mizoram	2196	0	0	60	2.73	2136	97.26
Sikkim	4286	669	15.60	2322	54.17	1295	30.23
Total	**63257**	**1911**	**3.02**	**5132**	**8.12**	**56214**	**88.86**

Table-6 Hydro Power Status of North-Eastern States
Data source: http://www.cea.nic.in/reports/hydro/he_potentialstatus_region.pdf

Among the eight states of the North East Arunachal Pradesh has the highest Hydro potentiality with 50328 M.W that is 79.56% of this region and 33.84 % of the country. Arunachal Pradesh itself could be the 'Power House' of India. As of October 2010, there were 132 memoranda of understanding (MOU) signed between the Government of Arunachal Pradesh and potential developers of hydropower projects with a total capacity of 40,140.5 MW. 120 of those memoranda are with private companies. [15]According to one estimate, in a ten-year period, Arunachal Pradesh proposes to add hydro-power capacity which is only a little less than the total hydropower capacity added in the whole country in 60 years of independence. Sikkim stands second with 6.77% and Meghalaya stands third with 3.78% hydro potential among all states of the region.

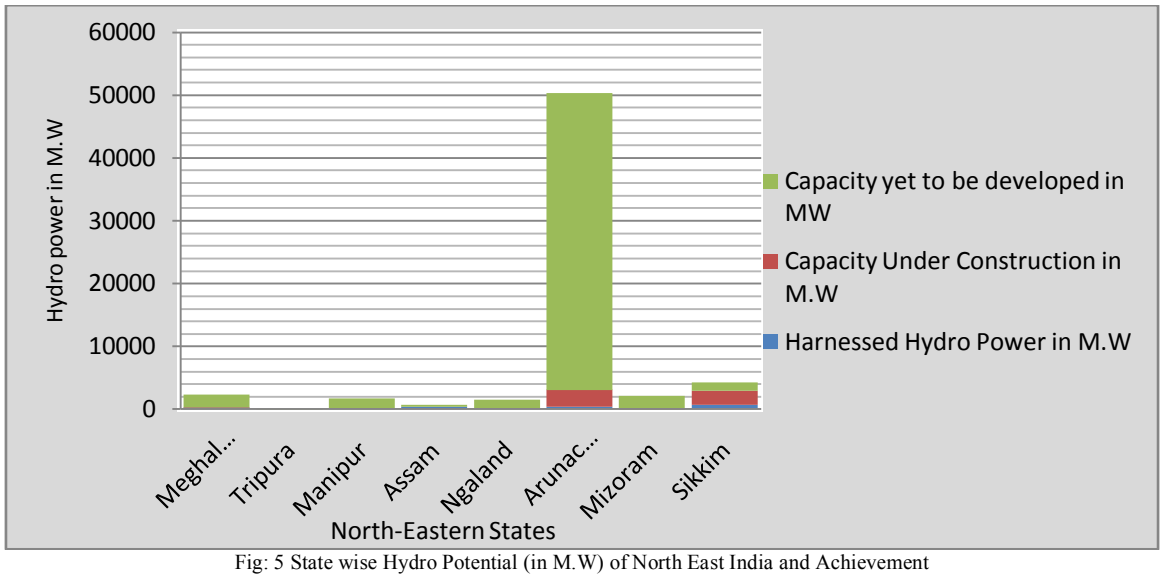

Fig: 5 State wise Hydro Potential (in M.W) of North East India and Achievement

Data Source: http://www.cea.nic.in/reports/hydro/he_potentialstatus_region.pdf

Among all the North-Eastern states Assam has harnessed maximum hydro potentiality 55.14% following Sikkim 15.6% and Meghalaya 11.78%. Arunachal Pradesh harnessed only 0.8% of it's' potentiality. In term of projects under construction Arunachal ranks 1st and Sikkim is 2nd in this region. After the competition of these projects where Sikkim will achieve 69.77 % of hydro potential, Arunachal Pradesh will get only 6.18% of its' potentiality. Among the all North Eastern states Sikkim and Assam are in advance stage in term of achievement of hydro potential and others are enough lagging behind. Over all development of the region is not satisfactory at all, this region has harnessed only 3.02% hydro potentiality, 8.12% is in capacity building stage and rest 88.36% yet to be harnessed.

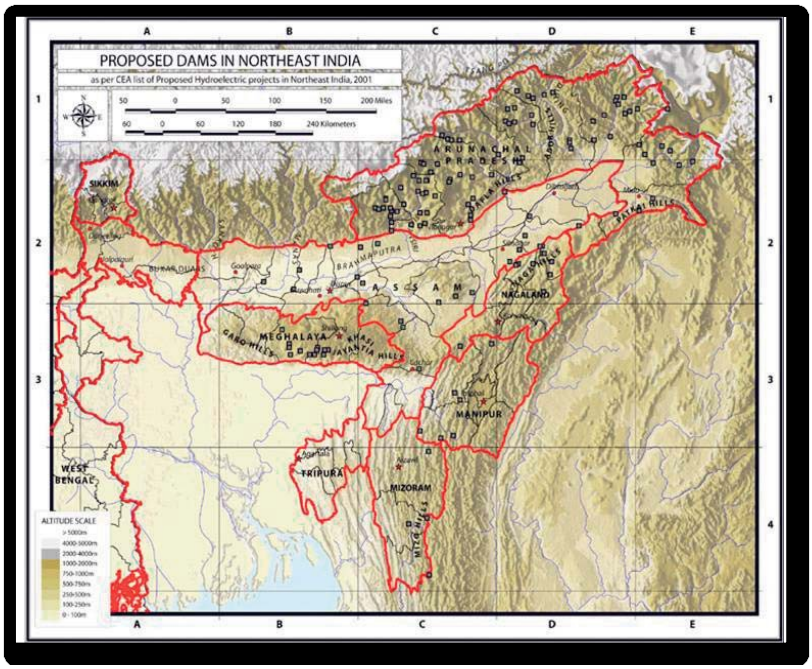

Fig6: **Central Electricity Authority projections (2001) identify 168 hydropower projects for total capacity of 63,328 MW in the Northeast**

From the above discussion it is clear that the North- Eastern States (including Sikkim) has the potentiality to be the 'Power House of India'. This region has one of the biggest water wealth of the world. Generating the hydro-power it could enhance economic growth of the region and take an important role in country's development. To achieve the Vision 2020, it is very important to complete these propose hydro projects of the region and transmit the power to others power regions of the country. After competition of these projects the entire economy could be changed. But as the 3rd law of Newton every development process has the advance

effects rather negative impacts. In this connection we have to ensure that the negative impacts are must be less than the beneficial effects. It is not so easy to tap the rivers or built hydro project as per our needs. There are several factors which should be kept in mind for proper sustainable development of hydro projects.

IV. Issues Related With Development of Hydro Power of North-East

Hydropower has immense benefits, these are as follows:

- It is a sustainable source of energy.
- India expenses huge amount of foreign exchange for energy requirement but hydropower involves no extra foreign exchange outgo.
- Hydropower is a no-inflation power. Water is the 'raw material' for power generation and it is free of inflation.
- Environment friendly – zero carbon emulation rate.
- Hydropower projects enhance socio economic development of remote areas with the development of project site.
- After competition of Hydropower project it is become very cost effective and renewable form of energy.
- It provides additional benefits like irrigation, flood control, tourism, transportation etc.

Even with these benefits, development of Hydropower in North-East India is not satisfactory at all in spite of its' huge potentiality due to several issues;

4.1 Seismicity and Tectonic Factors

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, the other five are Mexico, Taiwan California, Japan and Turkey.[16] The high seismicity in the region is attributed to the collision tectonics between the Indian plate and the Eurasian plate in the north and subduction tectonics along the Indo-Myanmar range (IMR) in the east (Dewey and Bird 1970; Kayal, 1996, 1998; Molnar and Tapponnier, 1975, 1977 and Sarmah, 1999). Verma *et al,* (1976, 1977) stated that the lithospheric subduction at the Himalayan belt ceased during Pliocene time and shallow seismic activity is the effect of continental-continental collision. Subduction, on the other hand, is still continuing in the IMR, which is evidenced by the intermediate to deep focus earthquakes in this range. Incidentally, maximum seismic activity has also been recorded in this range.[16] Based on the distribution of epicenters, fault plane solutions and geotectonic features, northeastern region can be divided into five seismo-tectonic zones. These are;

i)Eastern Himalayan collision zone, ii) Indo-Myanmar subduction zone, iii) Syntaxis zone of Himalayan arc and Burmese arc (Mishmi Hills), iv) Plate boundary zone of the Shillong Plateau and Assam Valley, v) Bengal Basin and Plate Boundary Zone of Tripura Mizoram fold belt,[16][17]

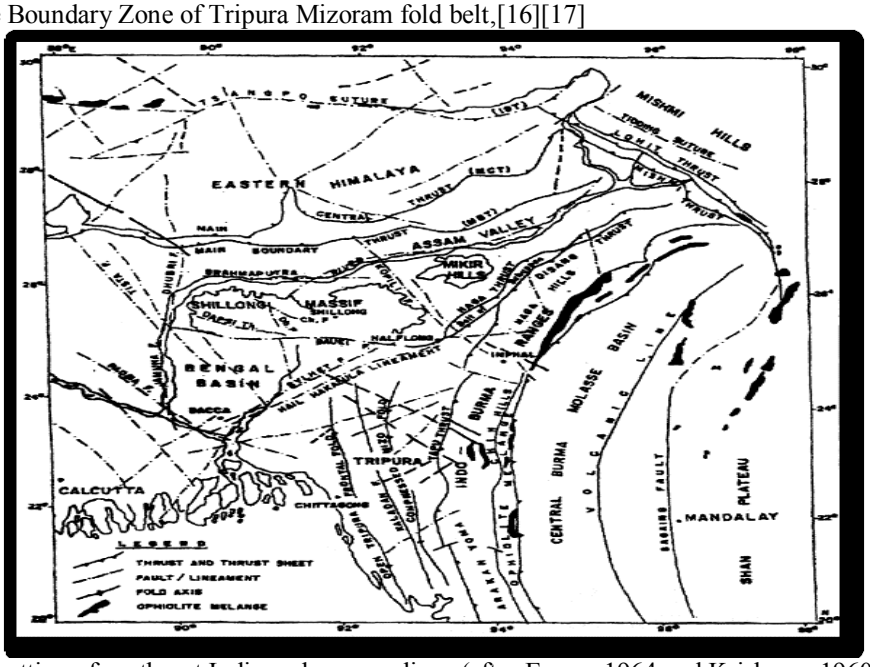

Fig7: Tectonic setting of northeast India and surroundings (after Evans, 1964 and Krishnan, 1960)

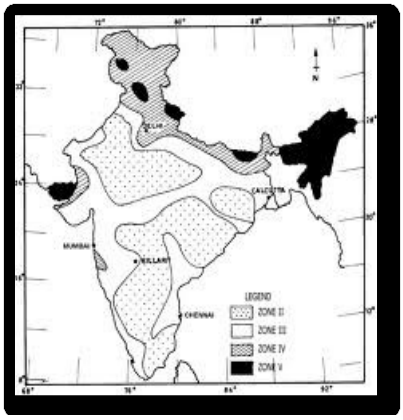

Fig8: Seismic Zones of India. (North-East is located in zone v, the highest zone, of the seismic zoning map of India.)

Sl no,	Name of Earth Quake	Felt Area	Magnitude in Richter scale
1.	Cachar Earthquake of 1869	6,65,600 sq. km	7.8
2.	Shillong Earthquake of 1897	30,000 sq. miles	8.7
3.	Srimangal Earthquake of 1918	9,24,320 km^2	7.6
4.	Dhubri Earthquake of 1930	9, 24,320 km^2.	7.1
5.	Assam Earthquake of 1950	N.A	8.6
6.	Indo-Myanmar Border Earthquake of 1988	N.A	7.8

Table.7 List of Remarkable Earthquakes of North-Eastern India
Source: Agarwal, P.N. (1986). A recent earthquake in Northeast India: *Proc. 2nd Int. Sem. On earthquake prognostic*, Berlin, June, 24-27, 1986, Friedr. Veiweg and Sohn. & History of Earth Quake USGS

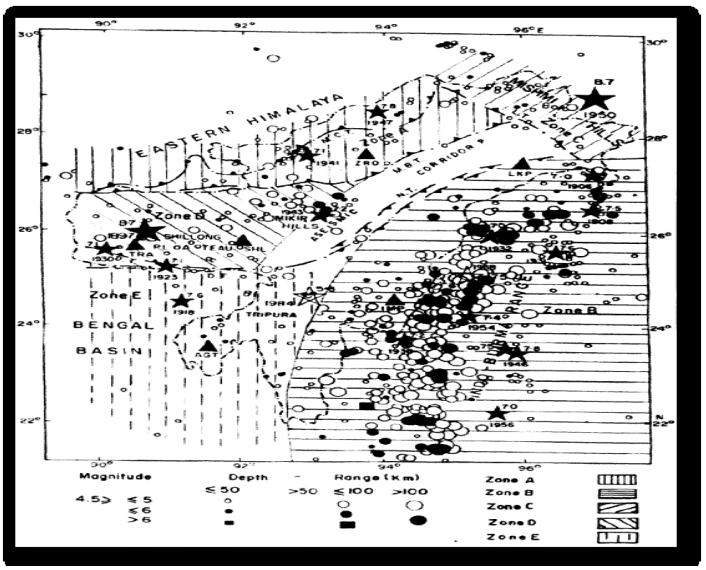

Fig10: Recent (1964-1996) seismicity in the northeastern region (after Kayal, 1998).
(Great and large earthquakes are shown by solid stars. Two open stars indicate the recent damaging earthquakes in the region. Solid triangles represent the permanent seismological observatories.)

Seismic factor is must be in consideration for the design of multipurpose water resource projects or hydroelectric projects of Northeast. There is a genuine argument that high dams should be built in the high seismic zones in the Himalayas or not. The areas near the Purbachal range and Main Boundary Fault are full of fault and weaker zones; these areas are not only seismically active but also have weaker lithologic character. Building of big dams or reservoir may increase the intensity and magnitude of earthquake.

4.2 Ecological Factors

North Eastern India ranks among the top 25 global biodiversity hotspots in the world, with 106 globally threatened species. [19] It has several indigenous species and human communities with their unique

features. This diversity has given them opportunity to co-exists and create a unique socio-cultural, agro-ecological and land-holding systems. High biological diversity is often related to the forest cover of a region. Most of the North Eastern states have more than 60% of their geographical area under forest cover, [19] a minimum suggested coverage for the hill states in the country. The percentage of forest cover was recorded during the years 2001 and 2003 by the Forest Survey of India is as follows:

North East States	Total area in km2	Forest cover in 2003	% of Forest cover in state
Arunachal Pradesh	83,743	68,019	81.22
Assam	78,438	27,826	24.04
Manipur	22327	17,219	77.12
Meghalaya	22,429	16,839	75.08
Mizoram	21,081	18,430	87.42
Nagaland	16,579	13,609	82.09
Tripura	10,486	8,093	77.18
Sikkim	7,096	3,262	45.97

Table.8 Scenario of Forest Cover in North East India
Source: State of Forest Report, 2003, Forest Survey of India, Ministry of Environment and Forests, Govt. of India.

The following figures highlight the biodiversity significance of the region (Hegde 2000, FSI, 2003)

i) Out of the 9 important vegetation types of India, 6 are (tropical moist deciduous forests, tropical semi evergreen forests, tropical wet evergreen forests, subtropical forests, temperate forests and alpine forests) found in the North Eastern region.
ii) These forests have 15,000 species of flowering plants. These include- 40 species of gymnosperms, 500 species of Pteridophytes, 825 species of orchids, 80 species of rhododendrons, 60 species of bamboo, 25 species of canes.

The Biodiversity Strategy and Action Plan for Northeast Eco-region states that 3624 species of insects, 64 species of amphibians, 137 species of reptiles, 65 species of bats, 1065 species of birds, 5 species of large cats and near about8250 elephants, 2575 rhinos are found in this region. Several indigenous species such as Yak (Bos grunnies, Markhor(Capra falconeri), Ibex (Capra ibex),Blue ship (Peseudois nayaur) dancing deer (Cervus eldi eldi) of Manipur, red panda of Sikkim and Arunachal Pradesh , Ganges Dolphin(platanista gangetica) are the unique creature of this region[18].

Construction of dams on across the river will must be impact on river ecosystems and the livelihoods and cultural heritage of the populations of river basins. Dams block rivers and reduce downstream river levels, thus reducing the amount of water in the downstream ecosystem .Fish habitat is further affected by alterations to the water temperature, oxygen and silt levels, and speed of river flows. As a result fish resources of Assam have been reduced dangerously. After competition of all the proposed dams more than 20% of forest of the region will be affected and can loss biodiversity. It is also can be said that these hydro projects on the Brahmaputra river system could be ruined the floodplain ecology of wetlands (*beels*) and grasslands in it s' valley [15]. So, the ecology of renounced Kaziranga National Park in Assam could be in danger.

4.3 Water Dispute with Neighboring Countries

The Brahmaputra is one of the world's largest rivers, with a drainage basin of 580,000 sq km, 33% of which is in India. Originating in the great glacier mass of Angsi or Chema-Yung-Dung in the Kailas range of southern Tibet at an elevation of 5,300 m, it traverses 1,625 km through Chinese territory and 918 km in India, [14] before a final stretch of 337 km through Bangladesh, emptying into the Bay of Bengal through a joint channel with the Ganga, commonly known as Meghan**.** The river carries the second largest sediment yield in the world, while it ranks fourth in terms of water discharge. In the course of its 2,880 km journey to the Bay of Bengal, the Brahmaputra receives as many as 22 major tributaries in Tibet, 33 in India and three in Bangladesh.[14] Many of the north bank tributaries are of Himalayan origin, fed by glaciers in their upper reaches. In true sense the Brahmaputra is a trans-boundary river and a matter of conflicts between China, India and Bangladesh. Within India the total basin area of this river spread over the states of Arunachal Pradesh, Assam, some part of Sikkim and West Bengal. Due to its' international status, there are several issues reading the water share of Brahmaputra.

4.3.1 Water Dispute with China:

North- East India is very dependent upon the Brahmaputra. Its' mean annual run-off volume is approximately 165,400 cubic km per annum that comes from Tibetan portion. [14] Therefore any interruption

with this flow of water may have a major impact on India and even more, on Bangladesh. In 2003 *People's Daily* reported about the launching of a feasibility study on diverting the Brahmaputra towards northern aired area of China. This report also added that China planning to built three dams across the Yarlung Tsangpo that will generate hydropower near of about 100,000 megawatts, one sixth of China's total electricity production, ranking second only to the 'Three Gorges Dam' over the Yangtze River.' In 2006 the detailed plan brought an announcement that the project would use the nuclear explosives to blast a tunnel 15 km long through the Himalayas to by-pass the river towards northern dry area. [20]

If China will complete its' dream project then the lower Brahmaputra basin will definitely face the water crisis during dry season. Arunachal Pradesh, India's most potential state of Hydro-Power would not able to achieve the supreme position. Riverine culture of lower Brahmaputra basin would be disturbed.

4.3.2 Water Dispute with Bangladesh:

Bangladesh is a riverine country. As a lower stream state it is one of the world's vulnerable in term of water recourse. Source of major rivers of the country is outside of its territory. Bangladesh is very anxious on the damming program of India. Bangladesh is mainly anxious about the Testa barrage and Tipaimukh project (1500 M.W) over the Barak River in Manipur. People of Bangladesh think that these two projects will disrupt the seasonal rhythm of the river system and will have an adverse effect on down stream's agriculture and fisheries. The government of Bangladesh has decided to send an expert team to the dam area to examine the features and likely impact on the environment of lower basins. The Barak River has entered Bangladesh as the Surma and Kushiara, which play an important role in keeping the ecological balance in the greater Sylhet region dotted with hundreds of water-bodies. Thousands of fishermen and farmers are dependent on the river. Tista is major source of water in Northern Bangladesh. Construction of dams without consideration the anxiety of Bangladeshi people may be affected the bilateral relationship.

4.4 Transmission Problem

CEA has planned to export the excess hydro power of North-East to other power region trough National Power Grid. The Power Grid Corporation of India Ltd has studied that to transmit this immense power; it has to develop long distance high-capacity transmission lines 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 with dense population.[11] The power from the neighboring countries (Bhutan and Myanmar) has also to pass through this narrow corridor. It would not be possible to construct so many transmission lines in Siliguri corridor. The Power Grid Corporation of India studied that only to transmit the hydro power of Kameng (600 megawatt) project it has to expense Rs. 11,000 million, near about 50% of the cost of the whole project. Similarly, in the case of the lower Subansiri (2,000 megawatts), the transmission cost would be near about Rs. 100 billion. [11]

4.5 Huge Investment

To achieve the hydro potentiality of North-East, the Central Government has to bear a huge amount of money. As we know the initial cost of any hydro project is very high. This cost includes the site development cost, resettlement and rehabilitation measures etc. Expenditure could be influx with the delayed of the project. The CEA has projected the expenditure for developing the hydro projects of North-East in different plan period as follows;

Plan	period	Benefits (megawatts)	Fund requirement (Rs. millions)
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

Table.9 Benefits and fund requirements by plan
Source: CEA

However, in 12th plan period the total energy expenditure is 829720 million rupees. [10] So, 30.17% of the total expenditure will be required for North-East. This huge expenditure is not easy for Indian economy.

V. Conclusions and recommendations

The immense unexplored hydropower potential of the Northeastern Region could meet the future energy demand of this region as well as India. More over this region has the potentiality to partially fulfill the energy demand of the neighboring countries especially Bangladesh. Exploring this untapped hydro power this region could be the '**Power House of India'**. However, we can't ignore the issues associate with the generation of North-Eastern Hydro Power. We have to seriously concern about these issues and take concrete steps to minimize the problems.

1. Construction of Big dams on highly seismicity area like North East is a vulnerable task. Technically it is possible to construct big dams on high hills area like Arunachal Pradesh or Sikkim. Before construct these big dams the proper investigation is very much needed through Environmental impact Assessment (EIA).For a proper EIA report, a multi disciplinary (joint task force of social scientist ,engineer, environmentalist) task force is needed to assessment the socio-environmental challenges associate with the proposed projects.
2. We should avoid the vulnerable areas (very high terrain with slope factor and week lithologic character) for big dams. Instead of big dams we can construct small dams like cheek dams (micro integrated control dams) according to the stream order and distribution of contours. Size and the height of these dams must be increased according their stream order. In this way an ascending order of dams in the catchment area can delayed the flood and provides relatively much more time to evacuate the people of lower area. This type of dams can also play vital role in village electrification generating the hydro power as well as can provide irrigational water to the agriculture field.
3. The rivers of North-Eastern states having hydro-potentiality are all trans-boundary River. So, water dispute is a common phenomenon in this part of the world. As a lower stream country Bangladesh is always anxious about Indian Hydro- Projects but it occasionally raises its voice on China's water piracy in Brahmaputra river system. Both India and Bangladesh have formed the Joint River Commission which discuss about the sharing of water wealth of India and Bangladesh. India can use this Joint River Commission to raise the protest against China's river divert project of Tsangpo or Brahmaputra.
4. Bangladesh is facing the serious scarcity of electricity. Its' various development projects are being hampered due to power shortage. If the Central Government will ensure to export a considerable amount hydro power to Bangladesh, the objection of Bangladeshi people may reduced on Indian Hydro projects of North-East. If it would be possible then the hydro power of North-East will be directly reached to rest part of the country through Bangladesh. In that case transmission loss will be minimized and transmission problem through Siliguri corridor could be resolved.
5. Everybody knows that transmission loss due to load factor is a serious problem of power grids. When the distance between demand area and supply area is minimized, only then transmission loss can be less. The power consumption rate of the North-Eastern States is lower than the national average; the annual per capita consumption in the region is 119 kilowatt/hours where national average is 390 kilowatt/hours. So, if the rate of village electrification and industrialization processes will be increased, the proper utilization of hydro-power of this region would be possible.
6. The development of the Northeastern Region's hydro potential should be satisfactory after the formation of a South Asia regional power grid system with equal transmission frequency with the cooperation of the countries in this region
7. Last but not the least, without the participation of local people any development activity can't be successful and it is also very truth that these development activities are also be acceptable to them. So, continuous awareness programs must be run in local people to enhance their perception on Hydro projects of North-East India.

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