Prepared for:
USAID-SARI/Energy Program
www.sari-energy.org

Regional Hydro-power Resources: Status of Development and Barriers

Bhutan

Nexant

September 2002

Regional Hydro-power Resources: Status of Development and Barriers
Bhutan

For

United States Agency for International Development

Under

South Asia Regional Initiative for Energy

Prepared by

Nexant SARI/Energy

List of Abbreviation

ADB	Asian Development Bank
BEA	Bhutan Electricity Authority
BPC	Bhutan Power Corporation
DOE	Department of Energy
Km	Kilometer
Mw	Megawatt
MU	Million units
MCM	Million cubic meter
RGOB	Royal Government of Bhutan
SAARC	South Asian Association of Regional Cooperation
UNDP	United Nations Development Program

Contents

Figure Page

Table Page

Maps

Executive Summary

Summary of the Document

- Bhutan is a landlocked sovereign country located in Eastern Himalayas with neighbor India in the South, East and West and China (Tibet) in the North. The area of the country is 46,000 Km ^{2} and has a population of 600,000 plus.

- The country is endowed with estimated hydro-power potential of 30,000 Mw and a fall from 7500 m to 200m across the N-S stretch make it naturally attractive and economical to develop hydro-power projects.

- Bhutan is still in a nascent stage of hydro-power development with a low base of only 344.458 Mw. The system peak load is about 77 Mw and **30%** of the population has access to electricity. The hydro-power generation is about **98%** and diesel generation is only **2%.** The power sector in the country right now is in a dynamic stage of development with corporatization of the Department with effect from 01-07-2002 and load dispatch network and attracting of foreign investment in Hydro-power Sector under active consideration.

- Bhutan has defined government "Plan and Policy for the country" and Energy Sector in general and Hydro-power in particular dovetail in the Policy

- Bhutan main constraints in Hydro-power development are Finance, Manpower/management, Machines/materials and Market.

- Strengthening of Transmission Lines for evacuating power from Bhutan is a great concern for Bhutan

- Bhutan is likely to have **100%** hydro-power generation for power except to opt for small other sources to make up for the right mix of generation beyond 2012.

Principal Results

- Hydro-power is the cheapest, clean and renewable source of energy

- Mini and Micro Hydro Schemes for remote and areas away from grid are important for socioeconomic development of the areas and to reduce the pressure on forest for fuels.

- Regional Grid to transfer power from surplus to deficit region is of prime importance for mutual benefits of the countries in the region.

- Environmental and ecological degradation in the hydro-power sites should be of temporary nature and there should be distinct upgrading of the Environment and Ecology after the completion of the project and need to be closely monitored. No project should be physically started till evacuation, resettlement and rehabilitation are complete. Economic

cost, environment and social cost and physical risks like heavy silting and earthquake in Himalayan Rivers are major deterrents for construction of high dams.

Next Step

- Carrying out of study and preparation of a study papers for Regional Transmission Grid on basis of demand and supply and technical and economical parameters. Initially this study could be carried out purely on technical and economical considerations unencumbered by the politics of the countries. A special study needs to be carried out assessing the demand and use of seasonal power thereby avoiding construction of high dam and storage.

- Hydro-power resources within the region can be optimally used for the mutual benefits of all the countries in the region with establishment of suitable mechanism for transfer of power.

- An ideal Power Purchase Agreement may be prepared as an offset of the above studies.

- The Technocrats and Economists of the regional countries could carry out the study and initially the following countries could be considered due to geographical reasons. Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka

- Regional forum for joint management and optimal use of Himalayan water for the mutual benefits of all stake-holding countries. Regional approach to the management and use of Himalayan water is the only key to harness the Himalayan Rivers for prosperity of the South Asian countries.

Bhutan, a Kingdom in eastern Himalayas is situated between India in the South, East, West and Tibetan Plateau in the North. It covers an approximate area of 46,500 sq. km spanning roughly 150 Km North to South and 300 Km East to West. The V-shaped valleys, formed by rivers and streams, between the high mountain ranges aligned north – south, drain the catchments from high altitude in the north to the plains in the south. Within a short distance of 175Km the altitudes decline from approx. 7500 m to only approx. 200 m above sea level. A few broad U-shaped valleys are also found in the eastern and central parts of the country.

The climate varies according to the latitude and altitudes with elevation pre-dominant factor. Two distinct seasons are summer and winter. The climate and soils determine the natural vegetation which generally can be divides as follows: the alpine tundra (above 3800m), the cold temperate forest (300-3800 m), warm temperate forest (200 – 300m), the semi-humid subtropical forest (700-2000) and humid subtropical rainforest (200- 2000m) to the south where the effect of summer rain is most prevalent.

Land also correlates fairly well with the altitude. Forest constitutes **72%** of the total land cover. In agriculture, the dominating land uses are Kamzing (dry land), Chhuzhing (wet land) and Tseri (slash and burn cultivation). Horticulture is on rise and more areas are being brought under horticulture. Arable land constitutes **7.7%** of the total land. Major crops are maize, wheat, barley, millet, potatoes, mustard, beans, ginger, chili and green vegetables. Oranges, Apples and cardamom, areca nuts are grown as cash crops. Livestock rearing on high altitude important activity and (Tsamdro) pasture is another land use. Improved pastures are being developed but the major pastures are state forests. One more land use is Sokshing which is an area from where the dries leaf litter is collected to make farm manure.

One of the most important natural resources of Bhutan is water. The mountainous terrain and the network of perennially flowing rivers and streams provide abundant renewable source of energy. The four major rivers, Ammochu, Wangchu, Sankosh and Manas, all of which flow in north-south direction with numerous small rivers and streams as tributaries, discharge into the Brahmaputra River in the plains of India and Bangladesh. The largest among these is the Manas, which has four major tributaries: the Gamrichu, the Kurichu, the Chamkharchu and the Mandechu. The Gamrichu drains Tashi Yangtshe and Trashigang districts. The Kurichu, only tributary of Manas with its origin in Tibet flows down Lhunste and Mongar districts. The Gamrichu and the Kurichu combine down stream to become the Dangmechu. The Mangdechu drains water shed between eastern and western Bhutan draining high altitude Bumthang Valley and flows through Trongsa. The Dangmechu and Mangdechu meet at the foothills a few kilometers from the Indo-Bhutan boarder to become Manas. There are smaller streams which originate and drain the lower hills in south-eastern part of the country and flows down to India without joining any of these major rivers. This includes the Dhansir(North) which flows past Trijunction (where Bhutan and the Indian states of Assam and Arunachal meet).

The Sankosh is the second largest river in Bhutan and has its origin in Lunana region, a region dotted with glacial lakes. Wangchu, known in India as Raidak, is a combination of three rivers meeting at Confluence. These three rivers flow through Thimphu, Paro and Haa in Western Bhutan. Wangchu merges with Sankosh before Sankosh drains into Brahmaputra

in Assam. This is the first river tapped for Hydro-power generation. Chukha with 336Mw is commissioned and Second stage Tala with 1041 is under construction.

The principal rivers of the West of the country are the Amochu or Toorsa originating in the Chumbi Valley in Tibet. Jaldhaka is a smaller river that flows between the Darjeeling Hills and Bhutan. It is the first river where India and Bhutan shared the water and agreed to set up a mini hydroelectric project in 1961.

The rivers with approximate length of 175 km and dropping down from about 7500m to 200m create a natural fall, which is ideal for development of Hydro-power. These rivers provide hydro-power theoretical potential of about 30,000 MW. Against the theoretical potential, techno-economically feasible hydro-power potential for development is about 16,280 MW.

Fuel wood consumption in Bhutan at 1.22 tons per capita is one of the highest in the world. Fuel wood accounts for approximately **77 %** of total energy consumption and virtually al non-commercial energy consumption since its forest resources provides abundant and readily available source of energy. This increases the pressure on the forest in Bhutan. Providing electricity to rural areas will decrease pressure on deforestation for fuel purposes Solar panels in remote areas have been provided for immediate requirement for lighting and small refrigeration for vaccines etc in remote areas and providing of cheap hydro-power through grid or micro/mini hydroelectric projects will be the least cost long term solution for the socio-economic development of the areas.

The Power Sector in Bhutan is being corportarized from 01-07-2002. The structural changes in the organization are also planned after 01-07-2002. Three organizations of Bhutan Electricity Authority (BEA), Department of Energy (DOE) and Bhutan Power Corporation (BPC) are planned after 01-07-2002.

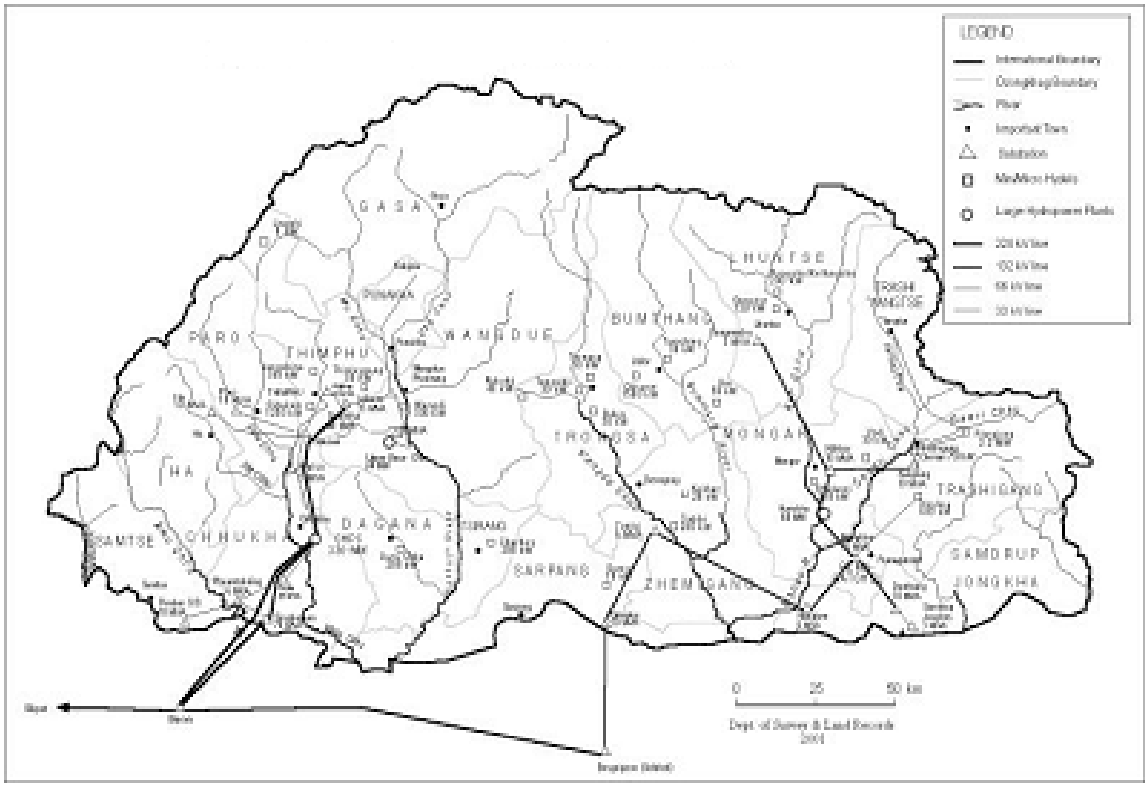


Figure 1-1 Existing Power Infrastructure at the end of year 2002

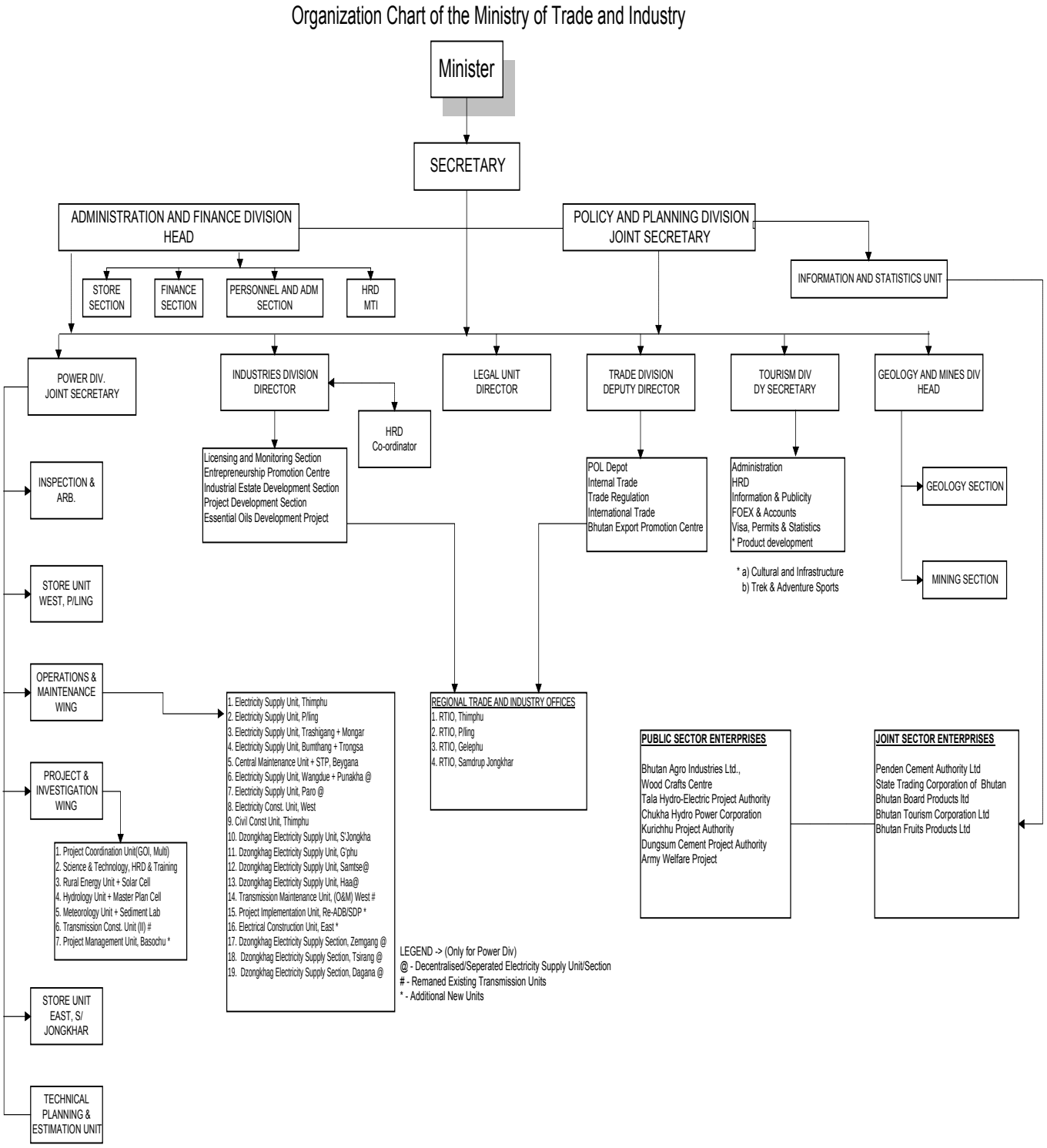


Figure 1-2 : Present Organization Structure of MTI

Organizational Structure of the Bhutan Electricity Authority
(BEA)

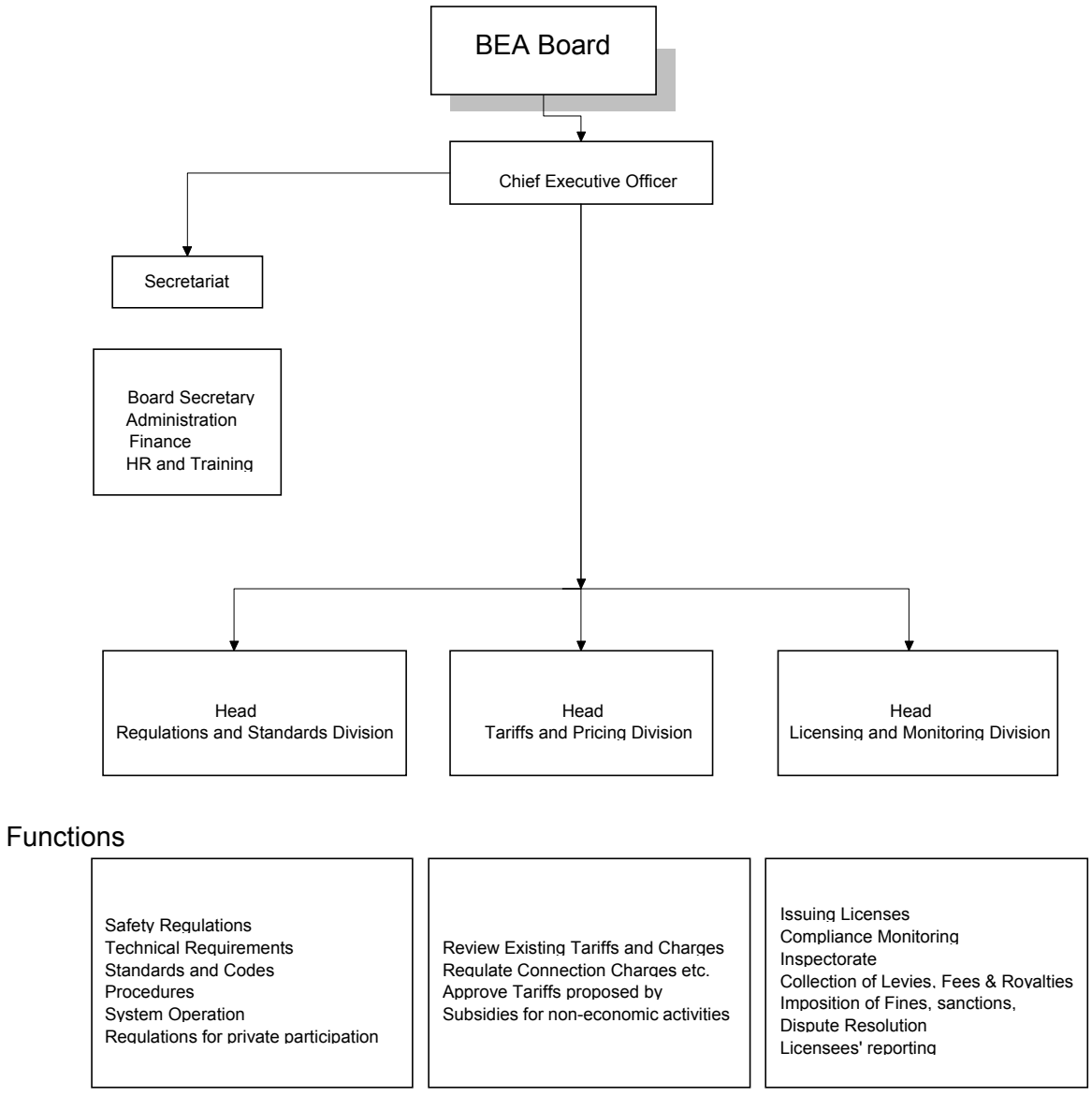


Figure 1-2 : Organization Structure of BEA after corporatization (after 01-07-2002)

Organizational Structure of the Department of Energy (DoE)

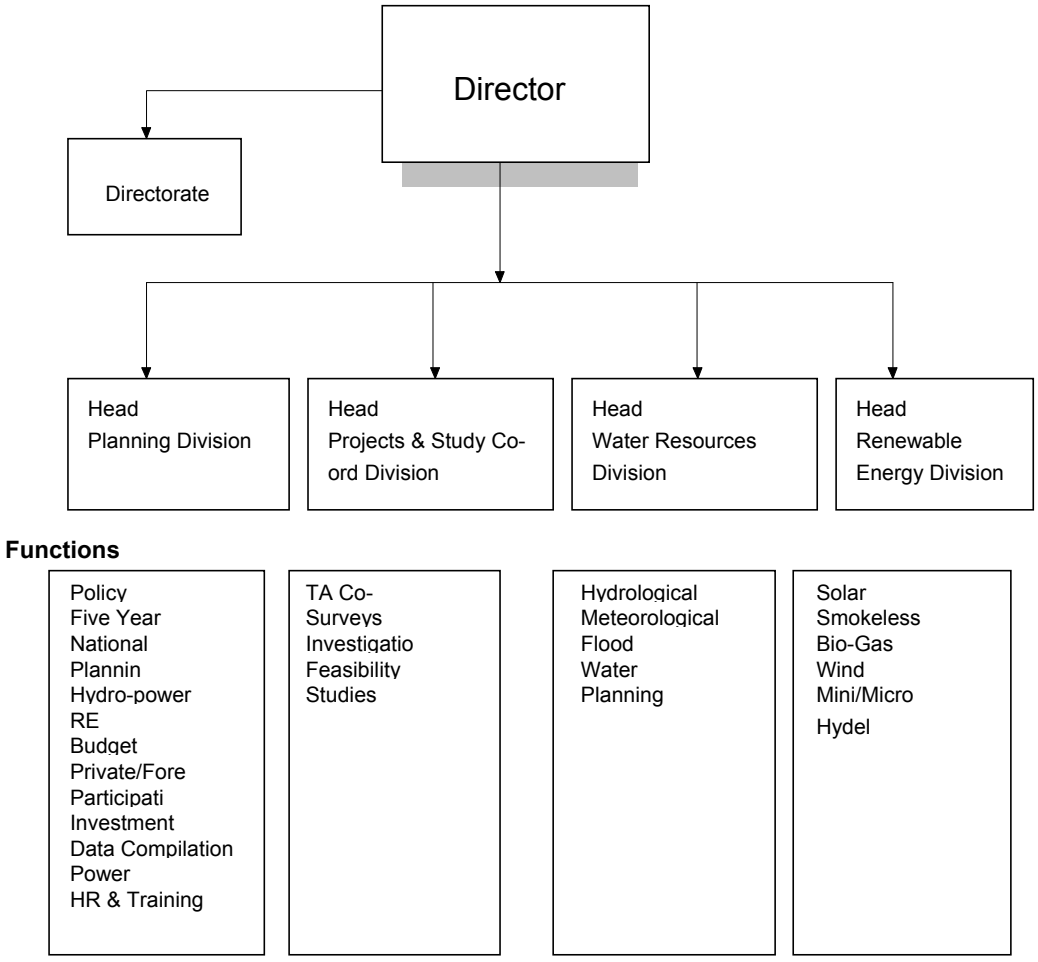


Figure 1-3 : Organization Chart of DoE after Corporatization (after 01-07-2002)

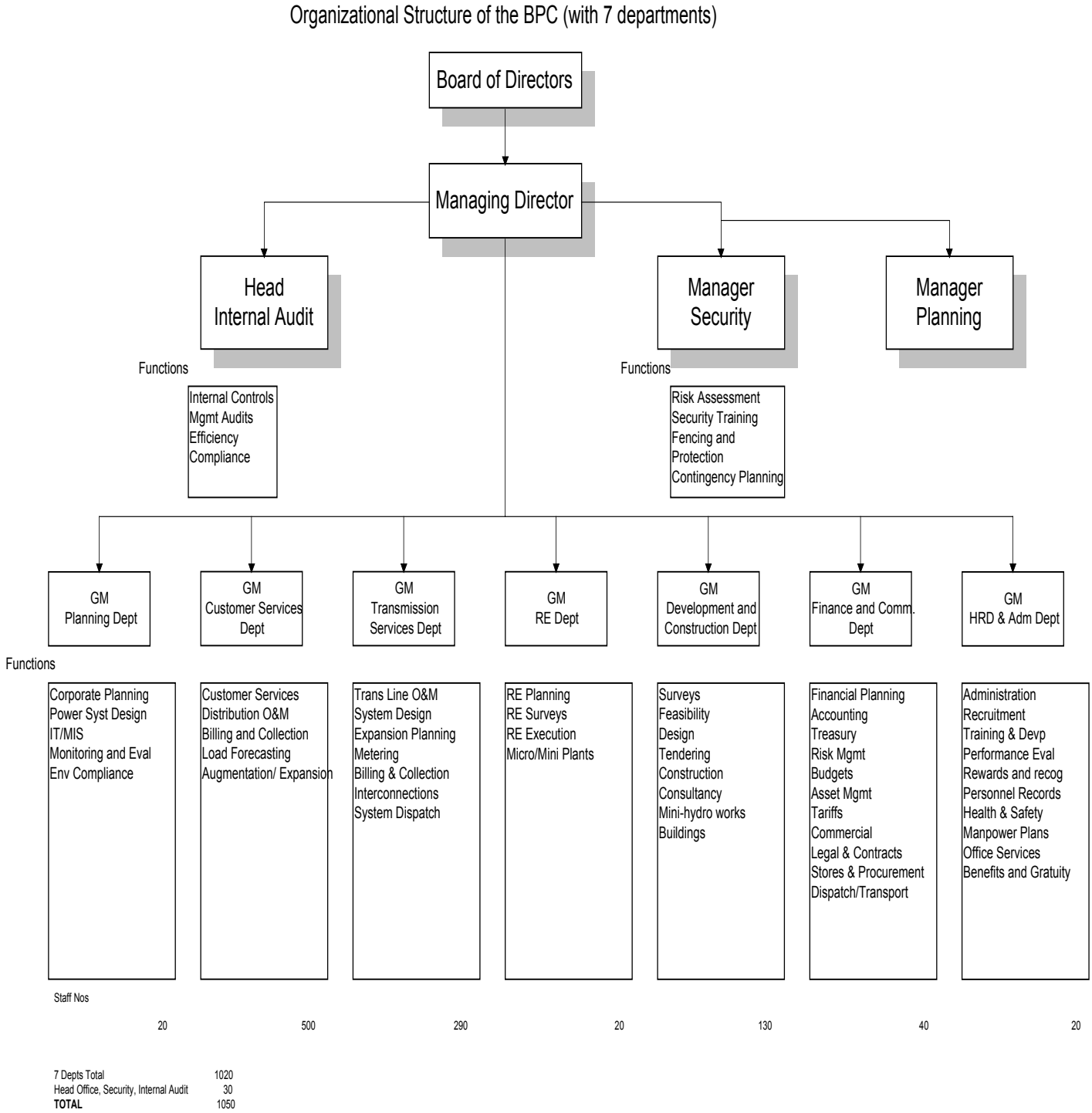


Figure 1-4 : Organizational Structure of BPC after Corporatization (after 01-07-2002)

Section 2 Background and Justification

The Advisory meeting on Hydro-power Development and Rehabilitation of the Hydro Plants in SARI region held in Sri Lanka has recommended a list of prioritized issues needing to be addressed in regional context. In order to address the issues raised in the workshop, particularly (i) Evaluation of unique economic and other benefits of a hydro-power project from regional perspective and develop a pricing mechanism of hydro-power. (ii) Develop a Regional Master Plan for exploitation of hydro-power resources and (iii) a Regional Least Cost Generation Expansion Plan, a comprehensive and authentic documentation of Regional Hydro-power Resources, the present status of its development, hydro-power development adopted and issues and barriers perceived by the partner countries in the development of hydro-power will be needed.

Section 3 Objective of the Report

To provide a Comprehensive and Authentic Reference Document, compiling of regional hydro-power resource development potentials (including parameters of all the identified projects), the present status of utilization of hydro-power resources, the future hydro-power development plans, policies currently followed for the hydro-power development and the problems and issues as perceived in the partner countries.

This study is predominantly based on secondary data available from various sources relevant to the power sector and hydro-power development in Bhutan and information collected from different government official of the agencies and from personal knowledge acquired on account of long association with the sector. The table 4-1 presents the details of the references and resource database reviewed and used in the present study.

Table 4-1 References and Resources Database

5	2005	Project System Development Project	Worley International	Asian Development Bank (ADB)		Internal
6	2006	Power Data	Division of Power	Royal Government of Bhutan	2002	Internal
7	2007	Removing Barriers to Mini and Micro Hydro-power. Bhutan		United Nations Development Progamme (UNDP)		Internal
8	2008	Policy and Legal Framework for Power Sector	PA Consulting Group	ADB	2001	Internal
9	2,009.00	Bhutan Power System Master Plan	Norconsult & Norpower	International Bank for Reconstruction and Development	1993	Internal

Designation:
Country Code and Report References would be designated by a 4-digits number. The first digit will denote the country and the last digits represent the serial number of the Report.

Bangladesh	1xxx
Bhutan	2xxx
India	3xxx
Nepal	4xxx
Sri Lanka	5xxx

One of the most important natural resources of Bhutan is water. The mountainous terrain and the network of perennially flowing rivers and streams provide abundant renewable source of energy. The rivers with approximate length of 175 km and dropping down from about 7500m to 200m create a natural fall, which is ideal for development of Hydro-power. These rivers provide hydro-power theoretical potential of about 30,000 MW. Against the theoretical potential, techno-economically feasible hydro-power potential for development is about 16,280 MW.

Table 5-1 Hydro-power Potential

S.No	Particulars	MW	%
1	Estimated Total Potential	30,000.000	
2	Developed	406.700	2.50
3	Techno-economically feasible for development	16,280.000	54.27
4	Under Construction (One Major Project)	1,041.000	6.39
5	On Pipe line of 9th Plan	1,487.000	9.13
6	Expected Total Development/under development by 2007	2,934.700	18.03

Note: Although the potential is very high, it may be economically feasible to develop only about 54% of the total estimated hydro potential within the country.

% calculation is made on the economical development potentials and not on total estimated hydro potential in the country.

Existing Projects:

Major Schemes:

- Chukha Hydroelectric Project: The Chukha Hydroelectric Project is on Wangchhu Basin in Chukha Dzong. The project was commissioned in year 1986.The scheme is run-of-the-river project with small diurnal intake pond.
  Rated Capacity: 336 Mw

- Kuri Chhu hydroelectric Project: The project developed on Kuri Chhu in Mongar district is a run-of-the-river type. The project was commissioned in 2001.
  Rated capacity: 60MW

- Baso Chhu Phase I: The project of two stage development is on the tributaries of Baso Chhu and Ruri Chhu to Sankosh river about 1.3 Km south of Wangdi Phudrong. This falls in Sankosh Basin. This is a run-of-the-river type project.
  The project was commissioned in year 2001.
  Rated capacity: 20 Mw

Medium or Small Scheme:

At present there is no medium sized hydro-power plants in Bhutan but number of small/mini hydroelectric power plants have been constructed (Ref Table 6.2). The projects have served useful purpose of providing energy in initial stages of development and also in remote areas when there was no grid and some palaces grid is still not connected. The small hydro-power projects provided useful indicators for development of power demand and also behavior of the streams. The data available are useful for planning major hydel projects.

Table 6-1: Current Hydro-power Utilization

PROJECT NAME	OWNER	YEAR OF INSTALLATION	OUTPUT		RESERVOIR		TYPE	POSSIBLE RENOVATION, MODERNIZATION AND UPGRADING
			CAPACITY IN MW	ANNUAL ENERGY IN MU	CAPACITY IN MCM	AREA IN KM2		
1	2	3	4	5	6	7	8	9
Chukha Hydel Project	Chukha Hydel Project Corporation	1986-88	4x84=336	1727	1.01	2.5km backwater	2	Too Early
Kurichu Hydel project	Kurichu Hydel Project Authority	2002	4X15=60	332	0.68	NA	2	Too Early
Baso Chu Hydel Project - I	Baso Chu Hydel Project Authority	2002	2x15=30	106			2	Too Early
Aggregated Mini Hydel	Department of Power	1972-1988	5.4	133.78	-	-	1	
			431.9					

Note:

MU = 1,000,000 KWh

MCM = Million Cubic Meters

* - Estimate

Column 8 - Type

1 - Run Of River

2 - Run Of River with pondage

3 - Peaking

4 - Multipurpose

5 - Storage

6 - Pump Storage

Table 6-2: Details of Existing Hydro Generating Stations

S.#	Station	Installed Capacity (No. x MW)	Generating Capacity (MW)	Year of Commissioning
1	Chukha	4 x 84.0	336.00	1986-88
2	Chumey (Bumthang)	3 x 00.50	1.00	1988
3	Gidakom (Thimphu)	5 x 00.25	0.50	1973
4	Jushina (Thimphu)	4 x 00.09	0.09	1967
5	Chennai (Tashigang)	3 x 00.25	0.25	1972
6	Rangjung (Tashigang)	2 x 01.10	2.20	1996
7	Khaling (Tashigang)	3 x 00.20	0.40	1987
8	Khalanzi (Mongar)	3 x 00.13	0.26	1976
9	KuriChu (Mongar)	3 X 15.0	45.00	2001
10	Wangdiphodrang	3 x 00.10	0.20	1972
11	Baso Chu(Wangdi)	2 x 15.00	20.80	2002
			406.70	

MICRO-HYDELS

S. #	Station	Dzongkhag	Capacity (kw)	Year of commissioning
1	Lhuentse	Lhuentse	20	1986
2	Thinleygaon	Thimphu	30	1986-87
3	Rukubji	Wangdi Phurdong	40	1986-87
4	Tansibji	Trongsa	30	1986-87
5	Trongsa	Trongsa	50	1986-87
6	Bubja	Trongsa	30	1986-87
7	Tamshing	Bumthang	30	1986-87
8	Ura	Bumthang	50	1986-87
9	Yadi	Mongar	30	1986-87
10	Kekhar	Zhemgang	20	1986-87
11	Surey	Sarphang	70	1986-87
12	Damphu	Tsirang	200	1991
13	Tintibi	Zhemgang	200	1992
14	Dagana	Dagana	200	1992
			1000	

Table 6-3 : Transmission Lines for Evacuating Power (in KM)

Particulars	220 KV	66 KV	132 Kv
Chukha Power			
CHP - Birpara	71.000 (D/C)*	-	
CHP - Singhigaon	31.900**	-	
CHP - Simtokha (II)	54.900**	-	
CHP - Gedu	-	20.100	
Gedu - Phuentsholing	-	17.700	
CHP - Confluence	-	36.700	
Confluence - Simtokha (I)	-	18.300	
Confluence - Ha	-	33.522	
Confluence - Paro	-	24.022	
Simtokha- Wangdiphudrong	-	26.023	
Phuentsholing - Gomtu	-	27.002	
Phuentsholing - Singhigaon	-	8.380	
Kurichu Power			
Gyelposing-Kilikhar			10.214
Kilikhar-Kanglung			29.807
Deothang-Nankhor			23.668
Gyeleposing-Nangkhor-Nganglam			68.900
Nganglam-Tintibi-Gelephu			129.200
Kilikhar-Luntshe			48.0000
Basochu Power			
Semtokha-Ruruchu	35		

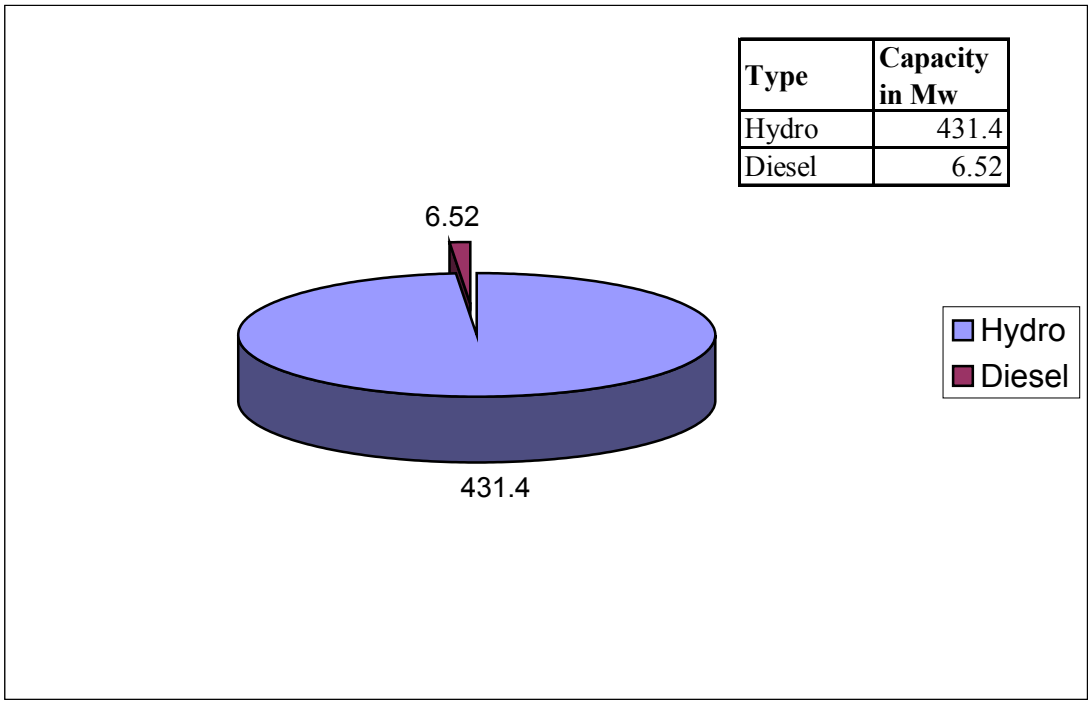


Figure 6-1 Power Matrix - 2002

Projects under construction:

- Tala Hydroelectric Project: This is second stage down stream development of Chhukha Hydroelectric Project on Wang Chhu in Tala in Wang Chhu basin. The project is likely to be commissioned in year 2005. Total volume of the storage is 9.80 million cum. The dam height is 92m.
  Rated capacity: 1020 Mw
  Annual energy capacity: 4865 Gwh

Table 7-1 : Data on New Projects Under Construction

PROJECT NAME	OWNER	EXPECTED YEAR OF COMMISSIONING	OUTPUT		RESERVOIR		TYPE	COMMENTS
			CAPACITY IN MW (No. of units X Unit Size)	ANNUAL ENERGY IN MU	CAPACITY IN MCM	AREA IN KM^2		
1	2	3	4	5	6	7	8	9
Tala Hydroelectric Project	Tala Hydroelectric Project Authority	2005	6x170=1020	4865	9.8	0.75	2	
Basochu-Stage II	BasoChu Hydroelectric Project Autority		40	186			1	
			1060					

Note:
MU = 1,000,000 KWh
MCM = Million Cubic Meters
* - Estimate

Note:
MU = 1,000,000 KWh
MCM = Million Cubic Met
* - Estimate

Column 8 - Type
1 - Run Of River
2 - Run Of River with pondage
3 - Peaking
4 - Multipurpose
5 - Storage
6 - Pump Storage

Thee major hydro generating stations except Chukha Hydel Projects are recently commissioned. Chukha Hydel Project also is only about 12 years old hence renovation/ modification/ upgrading/ life extension is not required. Both electro mechanical equipment and civil structures are of new technology. However, number of micro hydel stations of 20 to 30 years have been renovated and modernized.

Table 8-1 : Possible Renovation, Modernization, Upgrading and Life Extension of Existing Projects

COUNTRY NAME : BHUTAN

PROJECT NAME	OWNER	EXISTING CAPACITY IN MW	NEW ESTIMATED CAPACITY IN MW	ANNUAL ENERGY		POSSIBLE TYPES OF RENOVATION, MODERNIZATION, UPGRADING AND LIFE EXTENSION		
				EXISTING IN MU	NEW ESTIMATE IN MU	CIVIL	ELECTRICAL/MECHANICAL	COMM
1	2	3	4	5	6	7	8	9

----------NIL----------

Projects Planned:

- Punatsangchhu : Stage I of 870 MW hydroelectric project on Sankosh in Wangdi Phudrong district is planned.
- Mangdechu : Stage I of the hydro project is of about 360 MW on Mangdichhu in Trongsa district.
- Baso Chhu Satge II: The project as second stage development of Baso chhu is on Baso chhu and Ruri Chhu rivers in Wangdiphudrong district.
- Mini/ Micro hydel projects in Bumthang, Trashigang and other districts as indicated in the Annexure

Table 9-1: Projects Planned Up to 2012

PROJECT NAME	LEVEL OF STUDY	OWNER	EXPECTED YEAR OF COMMISS-IONING	OUTPUT		RESERVOIR		TYPE
				CAPACITY IN MW	ANNUAL ENERGY IN MU	CAPACITY IN MCM	AREA IN KM^2	
1	2	3	4	5	6	7	8	9
Mangdechu	4	Royal Government of Bhutan	2010	360	2000	6 hr storage		2
Punatsangchu	4	Royal Government of Bhutan	2012	870	4330	4 hr storage		2
		Total		1230				

Note:

Column 2 - Level of Study
- 1 - Desk Study
- 2 - Pre-feasibility Study including EIA
- 3 - Feasibility Study
- 4 - DPR (Detailed Project Report)

Column 9 - Type
- 1 - Run Of River
- 2 - Run Of River with pondage
- 3 - Peaking
- 4 - Multipurpose
- 5 - Storage
- 6 - Pump Storage

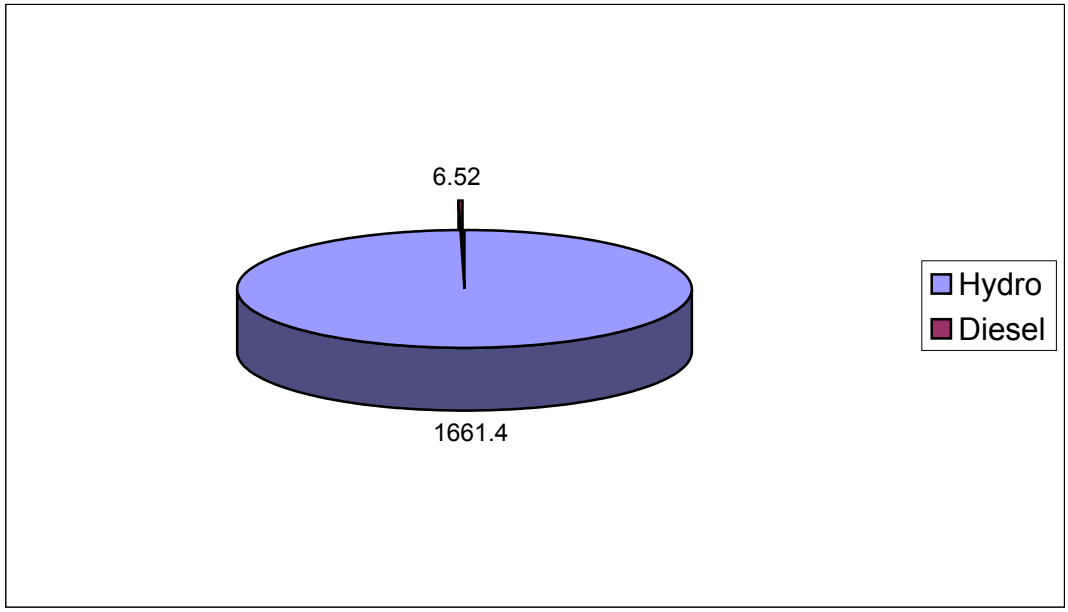


Figure 9-1: Power Matrix Upto 2012 - Planned

A shelf of projects has been identified for hydro-power development. These are mostly based on desk study with available field information. There is no proposal to take up the projects immediately but may be considered after 2012.

Table 9-2 : New Projects Beyond 2012

PROJECT NUMBER	LOCATION RIVER NAME AND ELEVATION	LEVEL OF STUDY	OWNER	EXPT YEAR OF COMMISS-IONING	OUTPUT		RESERVOIR		TYPE	IMPACTS	BENEFITS
					CAPACITY IN MW	ANNUAL ENERGY IN MU	CAPACITY IN MCM	AREA IN KM2			
	1	2	3	4	5	6	7	8	9	10	11
4.15 B	Bumthang 1480	2	RGOB	NA	492	1,860	NA	NA	2	separate sheet	
3.23B	Sankosh 800	2	RGOB	NA	480	2,160	NA	NA	2	separate sheet	
5.2 2)	Manas 95	2	RGOB	NA	1800	11,633	NA	NA	5	separate sheet	
5.03	Kuri 720	2	RGOB	NA	190	810	NA	NA	2	separate sheet	
1.02	Amo Chu 1440	2	RGOB	NA	269	1,000	NA	NA	2	separate sheet	
4.01	Tongsa, Chendebji 2240	2	RGOB	NA	136	510	NA	NA	2	separate sheet	
5.15	Manas, Kholong 1160	2	RGOB	NA	102	375	NA	NA	2	separate sheet	
3.03	Sankosh Mo 2120	2	RGOB	NA	207	780	NA	NA	2	separate sheet	
1.03	Amo Chu 800	2	RGOB	NA	167	625	NA	NA	2	separate sheet	
5.06	Kuri Chu 440	2	RGOB	NA	684	2,900	NA	NA	2	separate sheet	
4.14	Bumthang 2440	2	RGOB	NA	220	820	NA	NA	2	separate sheet	
3.25	Sankosh 560	2	RGOB	NA	142	640	NA	NA	2	separate sheet	
3.260 2)	Sankosh 175	2	RGOB	NA	376	2,471	NA	NA	5	separate sheet	
2.081 2)	Wang (Chukha III) 245	3	RGOB	NA	262	2,471	NA	NA	5	separate sheet	
3.12	Sankosh 1040	2	RGOB	NA	446	1,865	NA	NA	2	separate sheet	
2.06	Wang 840	2	RGOB	NA	194	850	NA	NA	2	separate sheet	
4.11	Bumthang 800	2	RGOB	NA	504	1,935	NA	NA	2	separate sheet	
4.02	Tongsa 1600	2	RGOB	NA	224	835	NA	NA	2	separate sheet	
4.15	Bumthang 2160	2	RGOB	NA	586	2,190	NA	NA	2	separate sheet	
1.051 2)	Amo Chu 225	2	RGOB	NA	353	1,923	NA	NA	5	separate sheet	
				Total	7,834						

Note:

Column 2 - Level of Study

1 - Desk Study
2 - Pre-feasibility Study including EIA
3 - Feasibility Study
4 - DPR (Detailed Project Report)

Column 9 - Type

1 - Run Off River
2 - Run Off River with pondage
3 - Peaking
4 - Multipurpose
5 - Storage
6 - Pump Storage

Table 9-3 : Impact and Benefits of New Projects

PROJECT NUMBER	LOCATION RIVER NAME AND ELEVATION		Impacts				Benefits				
			Transmission Line (km)	Approach Road (km)	Reservoir (Inundation)	Relocation (Pop.)	Renewable Source	Clean and Cheap	Low O&M Cost	Forest Conservation	Flood Control
4.15 B	Bumthang	1480	110	91	No	No	Yes	Yes	Yes	Yes	No
3.23B	Sankosh	800	120	< 5	Yes	No	Yes	Yes	Yes	Yes	Yes
5.2 2)	Manas	95	60	15	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5.03	Kuri	720	155	< 5	No	No	Yes	Yes	Yes	Yes	No
1.02	Amo Chu	1440	70	82	No	No	Yes	Yes	Yes	Yes	No
4.01	Tongsa, Chendebj	2240	137	12	No	No	Yes	Yes	Yes	Yes	No
5.15	Manas, Kholong	1160	175	< 5	No	No	Yes	Yes	Yes	Yes	No
3.03	Sankosh Mo	2120	105	30	No	No	Yes	Yes	Yes	Yes	No
1.03	Amo Chu	800	50	51	No	No	Yes	Yes	Yes	Yes	No
5.06	Kuri Chu	440	120	< 5	No	No	Yes	Yes	Yes	Yes	No
4.14	Bumthang	2440	134	20	No	No	Yes	Yes	Yes	Yes	No
3.25	Sankosh	560	110	< 5	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3.260 2)	Sankosh	175	80	22	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.081 2)	Wang (Chukha III	245	60	14	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3.12	Sankosh	1040	135	< 5	No	No	Yes	Yes	Yes	Yes	No
2.06	Wang	840	50	21	No	No	Yes	Yes	Yes	Yes	No
4.11	Bumthang	800	85	63	No	No	Yes	Yes	Yes	Yes	No
4.02	Tongsa	1600	130	12	Yes	Yes	Yes	Yes	Yes	Yes	No
4.15	Bumthang	2160	122	104	No	No	Yes	Yes	Yes	Yes	No
1.051 2)	Amo Chu	225	30	12	Yes	Yes	Yes	Yes	Yes	Yes	Yes

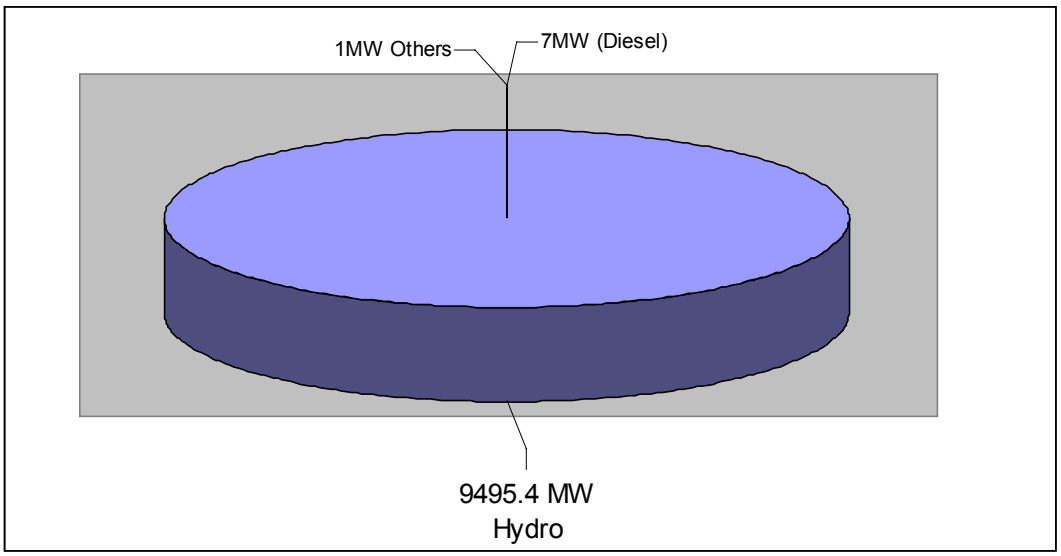


Figure 9-2: Power Matrix Beyond 2012 – Projected

10.1 Royal Government Policy and Plans

10.1.1 Self Reliance

10.1.2 Sustainability

All development is consistent with environmental conservation and cultural values, and it enhances the capacity of the country to increasingly provide from the own resources, the financial and other services required to support self-sufficiency.

10.1.3 Preservation and Promotion of Cultural and Traditional Values

The preservation and promotion of Bhutan's unique cultural and traditional values and nation's identity.

10.1.4 National Security

Security for the country, its people and its governing body, to lead a life and path of development of their own choice without unnecessary external interference. Bhutan's national security is also envisaged to benefit from continued collaboration with its friendly neighbors and donors.

10.1.5 Balanced Development

Balanced development involves, as far as possible, providing equal access to basic services and facilities of comparable quality to all Bhutanese wherever they reside in the kingdom.

10.1.6 Improving the Quality of Life

Measures to improve the quality of life in Bhutan will be directed not only to raising the income-earning capacity of the majority of the population, but also improving access to thee basic services such as education, health and facilities such as clean drinking water, sanitation and communications.

10.1.7 Institutional Strengthening and Human Resources Development

The strengthening of government institutions concerned with all stages of development from planning to implementation. In both public and private sectors, there is a need to improve management as well as supply the skilled manpower, currently in short supply, and to ensure its effectiveness and efficient utilization. To maximize the happiness of all Bhutanese and to enable them to achieve their full and innate potential as human beings. This is to be achieved within the framework of traditional values and ethics, and through concerted efforts to achieve sustainable improvements in the standard of living, the quality of life, and levels of well being and welfare.

10.1.8 Decentralization and Community Participation

Mobilize continued community participation for the essential services and have more local control over the prioritization of development works and implementation of the programs which affect them the most. Continue to decentralize to Dzongkag level.

10.1.9 Privatization and Private Sector Development

Government general role vis-à-vis private sector development will continue to be that of promoting an enabling environment. Provide increased training for entrepreneurs, as well as for personnel in the financial Institutions and to offer guidance on business management.

10.1.10 Environmental Conservation

To ensure that the choices made in response to many challenges that confront the nation embodying the principles of environmental sustainability and do not impair the biological productivity and diversity of the natural environment. This should be regarded as a developmental asset with a global significance to be protected and conserved in the interest of present and future generation.

10.1.11 Governance

To further develop our Institutions, human resources and system of governance in way that enable us to reduce our dependence on others, to manage increasingly complex process of development , and to enlarge opportunities for people at all levels to participate more fully and effectively in decisions that have bearings on their lives and livelihood and future of their families, communities and nation, Institutional development must embody a commitment to the principles of morality in government and of ethical behavior in the conduct of public affairs. It also promotes transparency and accountability, and be supported by the force of law that, while embodying a commitment to universal values, gives tangible expression to the distinctive features of Bhutanese culture and society.

10.2 Energy Sector Policy

Within the overall frame work of national policy**,** Power Sector policy is as given below:

- The effective management of water sheds is a key component of sustainable development. There are five main water sheds areas in the country.
- The development of Bhutan's energy sector is of crucial importance to the country and highest priority is placed on this sector.
- Development of hydro-power is considered important development strategy for enhancing the goal of self-reliance and sustainability.
- Fulfilling the domestic demand for electrical energy at minimum and uniform cost basis to all consumers within the country through safe, reliable and efficient distribution system.
- Enhance revenue and employment opportunities.

- Mitigate poverty and improve quality of life
- Ensure balanced regional development through provision of energy for industrial growth
- Reduce forest depletion and conserve natural resources
- Develop policy guideline and power tariff conducive to bilateral and multi lateral co-operation in hydro electric development.

Objectives

- Implement construction selectively of power projects for which detailed reports have been completed.
- Enhance revenue collection by efficient sources like hydro-power, which is renewable, environmentally clean and sustainable.
- Extend rural electrification
- Liaise with the other government agencies to ensure the protection of existing and future hydro-power catchments areas.
- Develop policy guidelines and power tariffs conducive to the promotion of bilateral and multilateral co-operation in hydro-power development.

10.3 Energy Sector

In the past the major source of energy was fuel wood. Even today the use of fuel wood is very high in rural areas. Kerosene and LPG are widely used for transport purposes. Hydroelectric power is assuming the leading roles in the consumption pattern of energy.

10.3.1 Solar Energy

Photovoltaic panels were installed in remote areas for schools, basic health units, monasteries and animal husbandry farms. This is an alternative for areas where grid supply is not economical and demand is limited.

10.3.2 Fuel Wood

Fuel wood continues to be the main source of energy for lighting and cooking in rural areas. At the national level it accounts for more than **75%** of total energy consumption. It is estimated that per capita consumption of firewood is 1.2 ton, which is tone of the highest in the world. In order to minimize wood consumption, extensive rural electrification are launched and is continuing as a priority activity in the sector.

10.3.3 Petroleum Products

Bhutan does not have source of petroleum within the country. Imported petrol and diesel consumption is increasing with development and extension of communication and massive

increase in population of vehicles. Kerosene oil import has increased with use of oil for lighting and cooking in rural areas. LPG is the main energy source for cooking in urban areas.

10.3.4 Hydroelectric Power

The main emphases is on the development of hydroelectric projects and replace fuel wood, kerosene oil and even LPG with cheaper, cleaner, hydroelectric power. In the power sector, development of hydro-power, its distribution and its management has been given highest priority.

Future Planning and Barrier

11.1 Future Planning

- The policy has clearly spelled out the course of action for the all the sectors of economy. Energy sector is considered one of the most important vehicles of economy of the country. The capital investment in this sector will continue to be around 20% or above of the total outlay of the country plan. The growth is expected to be about **18%** per annum. It is expected that the demand scene of India will continue to grow and all surplus power can be sold to India. It is hoped that the transmission grid in India will get strengthened and transfer of power will not be a bottleneck. It is also hoped that the "SAARC GRID" will be a reality and Bhutan will be an important supplier to the grid.

- The organization needs to be manned by highly professional and skilled personnel. In order to manage the sector efficiently and smoothly in highly technical and economical manner, induction of the suitable personnel and focused training of the engineers, managers and financial persons will be highly emphasized.

- National Load Dispatch Network will be created for efficient and economical management of the power generation and distribution.

- RGOB aspiration to contribute **49%** GDP from power sector will be realized.

- Rural Electrification to supply electric energy to more households in rural areas.

- Providing solar panels for lighting, refrigeration etc. in establishment like School, BHU, Monasteries and Animal husbandry farms in remote areas where grid supply or mini/micro hydro-power plants are not planned in near future.

- Investigate and prepare detailed project reports for major hydroelectric projects and also mini/micro hydel projects for future construction.

- Extend High and Low tension transmission lines to different areas to distribute power from the existing and planned hydroelectric projects.

- Human resources development by training in-country and outside the country.

- Royal Government with all the Legislative Acts, Firm Policy and Guidelines and Regulation will create an enabling environment for development of major hydroelectric projects.

11.2 Barriers

11.2.1 Finance

Hydro-power projects are highly capital intensive with long gestation time. The connected components of transmission lines and distribution lines are also very costly due to difficult mountainous terrain, remoteness of places and spare population in remote areas. Mobilization of finance at acceptable and profitable terms is becoming more and more difficult. Financial arrangement on acceptable terms is a constraint in construction of major hydro-power projects,

11.2.2 Market

The consumption of power within the country is very limited and not expected to be more than **11%** of the total generation. Power will have to be sold to the neighboring countries. The present available market is India only and India also has a very weak grid in Border States of W.Bengal and Assam of India. There is a plan afoot in India to upgrade the grid to 750Kv and connect with North of India. Unless the grid is strengthened, there will be very big problem of evacuating surplus power of Bhutan to different parts of India and Assam and West Bengal is not expected to absorb power to this extent, in fact, these states are likely to be surplus in power on their own. If ever "SAARC GRID" materializes then there is a hope for all the countries have sufficient power and Bhutan to play an important role as a provider.

11.2.3 Machines/Materials

All the machinery and equipment required for the projects are imported from outside. Bhutan has an option to opt for the best and efficient technology for construction, operation and management. Bhutan will have to depend entirely on outside companies for spares and major repairs and rectification. Choices will have to be for technology with modern technology but with appropriate sophistication. Construction materials also mostly come from outside. Major items of all construction works are imported to the country. This will continue to be a major constraint in development of major hydro-power project.

11.2.4 Manpower/Management

There is an acute shortage of trained manpower within the country. All developmental sectors are competing for small pool of trained technical manpower in the country. Highly trained and skilled manpower and professionals and experience are required for the major hydro-power projects from the inception to the completion and thereafter to operate and manage the system. Emphasis is already given to develop human resources by attaching to the major projects, associating with ex-pat experts, sending engineers for Masters Courses in different fields of technical and management and also sending students for graduate courses in Engineering. An Engineering College is also started in the country. In not so distant future the manpower problem will be greatly eased but dependency on Machines and materials will continue.

11.2.5 Act and Regulation

A well defined policy, guidelines, regulation and Act passed by the Assembly for development and financing of the major hydro-power projects will have to be in place to attract foreign or private investment in the sector. Royal Government with all the Legislative Acts, Firm Policy and Guidelines and Regulation will create an enabling environment for development of major hydroelectric projects. For a foreign investment or private investment, security of their investment and returns on investment legally protected is of prime importance. The assembly in 2001 has passed electricity Act. Corporatisation of the department of power is already under active consideration and likely to be effected by next fiscal year. Legislation of all relevant acts will greatly help corporations and also interested investors.

- Bhutan is endowed with natural hydro-power potential and development of the hydro-power resources is the least cost solution to meet the energy requirement for internal consumption and export to neighboring countries to increase revenue of the country.

- Water has been rightly described as the " liquid gold" for Bhutan . Appropriate exploitation of the hydro-power resources will bring economic prosperity to the country.

- Run of the River or Run of the River with pondage is the quick, safe and cost effective approach to the development of hydro-power resources in Bhutan despite its limitation of high seasonal variation.

- Mini and Micro hydel schemes will continue to play important role in providing electricity to remote areas for lighting, heating, small scale industries development and general socioeconomic uplift of the people and also to reduce pressure on the forest for fuel wood.

- There must be complete dedication for the cause of environment and ecological balance on the parts of all concerned in general and administrators and Engineers in particular. There should be concerted efforts to monitor and implement all plans of afforestation and reclamation and leave the project areas better than it was before the start of the Project.

- Bhutan will have to opt for the latest labour saving technology of construction for construction of Hydro-power Projects to overcome the constraint of manpower shortage. The sophistication in operation should be appropriate to the plans and program of the skilled manpower development of the country.

- Strengthen the Power Sector by efficient organization, high managerial capability and proper legislation.

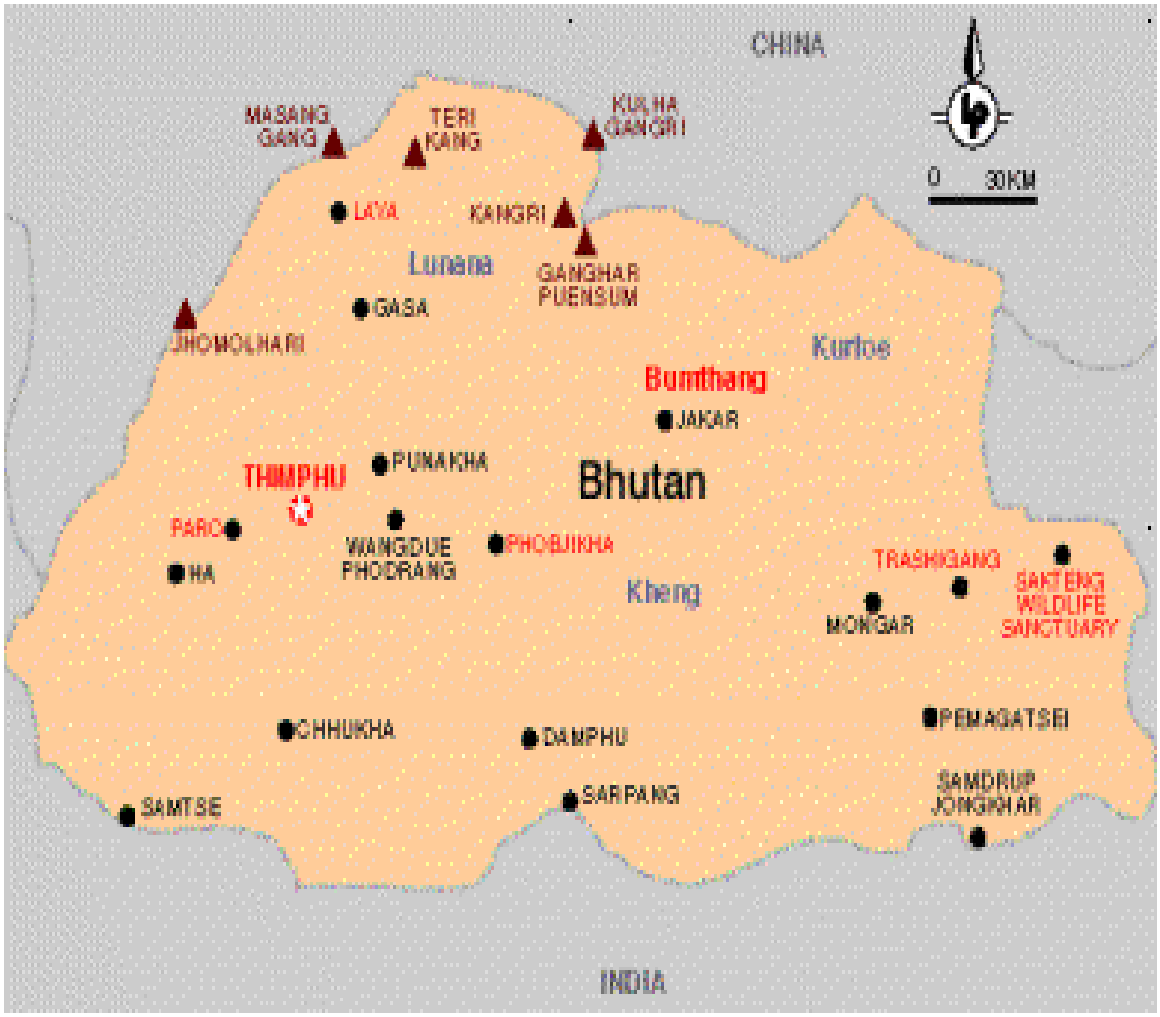
- BOOT and IPP are distinct choices for mobilization of resources for the development of major hydel projects.

- Regional Approach to the management of water and production of electricity is imperative.

- A forum of Scholars, Academics, Former bureaucrats and technocrats of the Regional countries to discuss and exchange views and express fear and reservation of the countries and arrive at an ideal acceptable solution to make implement able plans to present to respective government for consideration, may be step forward towards solution and to keep water politics at abeyance. The plan must make an economic sense but at the same time it must prepare a fertile ground to sow the idea of extensive regional cooperation in field of hydro-power in particular and electricity in general for benefits of all the countries. Many a schemes of value have failed because of "Public Awareness".

Location Map

Country Map


CHINA
MASANG GANG
TERI KANG
KULHA GANGRI
0 30KM
LAYA
KANGRI
Lunana
GANGHAR PUENSUM
GASA
JHOMOLHARI
Kurtoe
Bumthang
JAKAR
PUNAKHA
THIMPHU
Bhutan
PARO
HA
WANGDUE PHODRANG
PHOBJIKHA
Kheng
TRASHIGANG
MONGAR
SAKTENG WILDLIFE SANCTUARY
PEMAGATSEL
CHHUKHA
DAMPHU
SAMDRUP JONGKHAR
SARPANG
SAMTSE
INDIA