People's Republic of Bangladesh
Power Division, Ministry of Power, Energy and Mineral Resources (MOPEMR)

Data Collection Survey on Electricity Interconnectivity among Neighboring Countries in the People's Republic of Bangladesh

Final Report

April 2016

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company Holdings, Inc.
Tokyo Electric Power Services Co., Ltd.

BD
CR(10)
16-001

Table of Contents

List of Figures

List of Tables

List of Photos

Abbreviations

Abbreviation	Word
AAAC	All Aluminum Alloy Conductor
ABT	Availability Based Tariff
AC	Alternating Current
ADB	Asian Development Bank
APSCL	Ashuganj Power Station Company Ltd.
BBIN	Sub-regional Grouping of Bangladesh, Bhutan, India and Nepal
BEA	Bhutan Electricity Authority
BEC	BIMSTEC Energy Center
BERC	Bangladesh Energy Regulatory Commission
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BOCM	Bilateral Offset Credit Mechanism
BOT	Build, Own, Transfer
BPC	Bhutan Power Corporation
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
BTB	Back-to-Back
BTN	Bhutanese Ngultrum
CA	Competent Authority
C/C	Combined Cycle
CCGT	Combined Cycle Gas Turbine
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CFTPP	Coal-fired Thermal Power Plant
CPGCBL	Coal Power Generation Company Bangladesh Ltd
CPP	Captive Power Producer
CUL	Compensation Under the Law
DAC	Day Ahead Contingency Contract
DAM	Day-Ahead Market
DAS	Day Ahead Spot Contract
DC	Direct Current
DC	Deputy Commissioner
DEO	Dzongkhag Environment Officer
DEP	Department of Electric Power
DESA	Dhaka Electric Supply Authority
DESCO	Dhaka Electricity Supply Company
DFR	Draft Final Report
DG	Director General
DGPC	Druk Green Power Corporation
DHMS	Department of Hydro-Met Services
DHPI	Department of Hydropower Implementation
DHPP	Department of Hydropower Planning
DHPS	Department of Hydropower & Power System
DOE	Department of Environment
DOED	Department of Electricity Development
DPDC	Dhaka Power Distribution Company
DPR	Detailed Project Report
DRE	Department of Renewable Energy

Abbreviation	Word
EA	Environmental Assessment
EAC	Expert Appraisal Committee
EA&CEI	Electric Advisor and Chief Electric Inspector
EC	Environmental Clearance
ECC	Environmental Clearance Certificate
EGCB	Electricity Generation Company of Bangladesh
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation
EMRD	Energy and Mineral Resources Division
EPA	Environment Protection Act
EPD	Energy Planning Department
EPS	Electric Power Survey
ER	East Region
ESE	Electricity Supply Enterprise
ETFC	Electricity Tariff Fixation Commission
EWG	Energy Working Group
EWI	East-West Interconnector
EXIM	Export-Import
FC	Forest Clearance
FDI	Foreign Direct Investment
FIRR	Financial Internal Rate of Return
FR	Final Report
F/S	Feasibility Study
FY	Fiscal Year
FYP	Five Year Plan
GDP	Gross Domestic Product
GHG	Green House Gas
GMR	Name of Indian private company
GOB	Government of Bangladesh
GOI	Government of India
HPGE	Hydropower Generation Enterprise
HPP	Hydro Power Plant
HR/D	Human Resource Development
HRT	Head Race Tunnel
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
HWL	High Water Level
IA	Impact Assessment
ICR	Inception Report
IEA	International Energy Agency
IEE	Initial Environmental Examination
IEX	Indian Energy Exchange
IFI	International Financial Institution
IG	Inter-Governmental
INR	Indian Rupee
IPP	Independent Power Producer
IRADe	Integrated Research and Action for Development
IRR	Internal Rate of Return
IS	Indian Standards

Abbreviation	Word
ISGS	Inter-State Generating Station
ISRM	International Society for Rock Mechanics
ISTS	Inter State Transmission System
IT	Information Technology
ITR	Interim Report
IUCN	International Union for Conservation of Nature
JCM	Joint Crediting Mechanism
JEC	Japanese Electromechanical Committee
JFJCM	Japan Fund for the Joint Crediting Mechanism
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
JTT	Joint Technical Team
JV	Joint Venture
JWG	Joint Working Group
LAO	Land Acquisition Officer
LGBR	Load Generation Balance Report
LILO	Line-In Line-Out
LNG	Liquefied Natural Gas
MBT	Main Boundary Thrust
MD	Managing Director
MEPE	Myanmar Electric Power Enterprise
MePGCL	Meghalaya Power Generation Company Limited
MIGA	Multilateral Investment Guarantee Agency
MIS	Management Information System
MOAF	Ministry of Agriculture and Forests
MOE	Ministry of Energy
MOEA	Ministry of Economic Affairs
MOECAF	Ministry of Environmental Conservation and Forestry
MOEF	Ministry of Environment and Forests
MOEFCC	Ministry of Environment, Forest and Climate Change
MOEP	Ministry of Electric Power
MOEST	Ministry of Environment, Science, and Technology
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MOP	Ministry of Power
MOPEMR	Ministry of Power, Energy and Mineral Resources
MOU	Minutes of Understanding
MPP	Merchant Power Plant
MTI	Ministry of Trade and Industry
NE	North East
NEA	Nepal Electricity Authority
NEC	National Environment Commission
NEEPCO	North Eastern Electric Power Corporation
NER	North East Region
NEXI	Nippon Export and Investment Insurance
NGL	Natural Gas Liquid
NGO	Non-Government Organization
NHPC	National Hydro Electric Power Corporation
NLC	National Land Commission
NLDC	National Load Dispatch Center

Abbreviation	Word
NOC	No Objection Certificate
NORPLAN	Name of Norwegian Company
NPPF	National Pension & Provident Fund
NR	North Region
NRRP	National Resettlement and Rehabilitation Policy
NSB	National Statistics Bureau
NTGMP	National Transmission Grid Master Plan
NVVN	NTPC Vidyut Vyapar Nigam Limited
NWPGCL	North West Power Generation Company Ltd.
O/H	Overhead
O&M	Operation and Maintenance
PAPs	Project Affected Persons
PAVA	Property Assessment & Valuation Agency
PBS	Palli Bidyut Samity
PC	Power Cell
PD	Power Division
PDA	Project Development Agreement
PFS	Pre-feasibility Study
PGCB	Power Grid Company of Bangladesh
PGCIL	Power Grid Corporation of India Limited
PM	Prime Minister
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
P/S	Pooling Station
PSMP	Power System Master Plan
PSPP	Pumped Storage Power Plant
PTA	Power Trade Agreement
PTC	Name of Indian company
PV	Photovoltaic
PXIL	Power Exchange India Limited
RBL	Present Riverbed Level
R&D	Research and Development
REC	Renewable Energy Certificates
REDF	Renewable Energy Development Fund
RFCTLARRA	Right to Fair Compensation and Transparency in Land Acquisition Rehabilitation and Resettlement Act
RGOB	Royal Government of Bhutan
RLDC	Regional Load Dispatch Center
RMR	Rock Mass Rating
ROW	Right-of-Way
RPCL	Rural Power Company Limited
R&R	Rehabilitation and Resettlement
SAARC	South Asian Association for Regional Cooperation
SARI/EI	South Asian Regional Initiative for Energy Integration
SARPES	South Asia Regional Power Exchange Study
SASEC	South Asia Sub-regional Economic Cooperation
SCADA	Supervisory Control And Data Acquisition
SE	Superintending Engineer
SEAC	State Level Expert Appraisal Committee
SEC	South Asian Association for Regional Cooperation Energy Centre

Abbreviation	Word
SEIAA	State Environment Impact Assessment Authority
SIA	Social Impact Assessment
SIPP	Small Independent Power Producer
SJVNL	Name of Indian company
SLDC	State Load Dispatch Center
SPC	Special Purpose Company
SR	South Region
S/S	Substation
SWS	Sakteng Wildlife Sanctuary
TA	Technical Assistance
TAM	Term-Ahead Market
TBM	Tunnel Boring Machine
TF	Task Force
THDC	Name of Indian company
T/L	Transmission Line
TOR	Terms of Reference
U/G	Underground
UP	Uttar Pradesh
USAID	United States Agency for International Development
USD	United States Dollar
WARPO	Water Resources Planning Organizations
WB	World Bank
WECS	Water and Energy Commission Secretariat
WR	West Region
WZPDCL	West Zone Power Distribution Company Limited
XLPE	Cross-Linked Polyethylene
YESB	Yangon City Electricity Supply Board

Chapter 1 Introduction

1.1 Background of the Survey

The power and energy sector in the People's Republic of Bangladesh ("Bangladesh") excessively depends upon electric thermal generation with domestic natural gas (as of December 2013, 64% of the total generation capacity). Therefore, the diversification of base-load fuel resources is one of the most highly prioritized issues for securing a stable electricity supply. Industrial diversification and advancement are also essential in order to achieve further economic development in the country. To this end, improvement of the quality of the power supply, such as stabilization of network voltage and frequency, is a prerequisite. In addition, in anticipation of the growing share of coal-fired thermal power generation in the medium and long term, the exploitation of renewable energy resources with low environmental burden under the climate change perspective is envisaged.

On-grid large-scale hydropower development seems to be an effective measure to overcome the aforementioned issues. However, due to its flat geographical features, Bangladesh lacks prospective hydropower potential over 1 MW apart from the existing Kaptai hydro power plant (230MW). In contrast, there is abundant water power resource potential in the countries surrounding Bangladesh, namely Bhutan, Nepal, Myanmar, and the Indian States of the North East and West Bengal (collectively "neighboring countries"). Thus, it is expected that Bangladesh imports electricity out of such hydropower generation via power interconnections with such neighboring countries for stable base load supply, energy fuel diversification, and climate change mitigation.

On the other hand, Bangladesh's power development scenario may expect an electricity supply surplus around the year 2030. This will enable Bangladesh not only to import electricity but also to transit and even export electricity to neighboring countries through power interconnections, contributing to electricity demand and supply balancing in the country and neighboring countries and foreign exchange earnings.

1.2 Purpose of the Survey

1.2.1 Purpose of the Survey

The purpose of the Survey is to analyze the electricity interconnectivity among the neighboring countries of Bangladesh, and to collect information on the potential hydropower generation projects in those countries to be imported to Bangladesh.

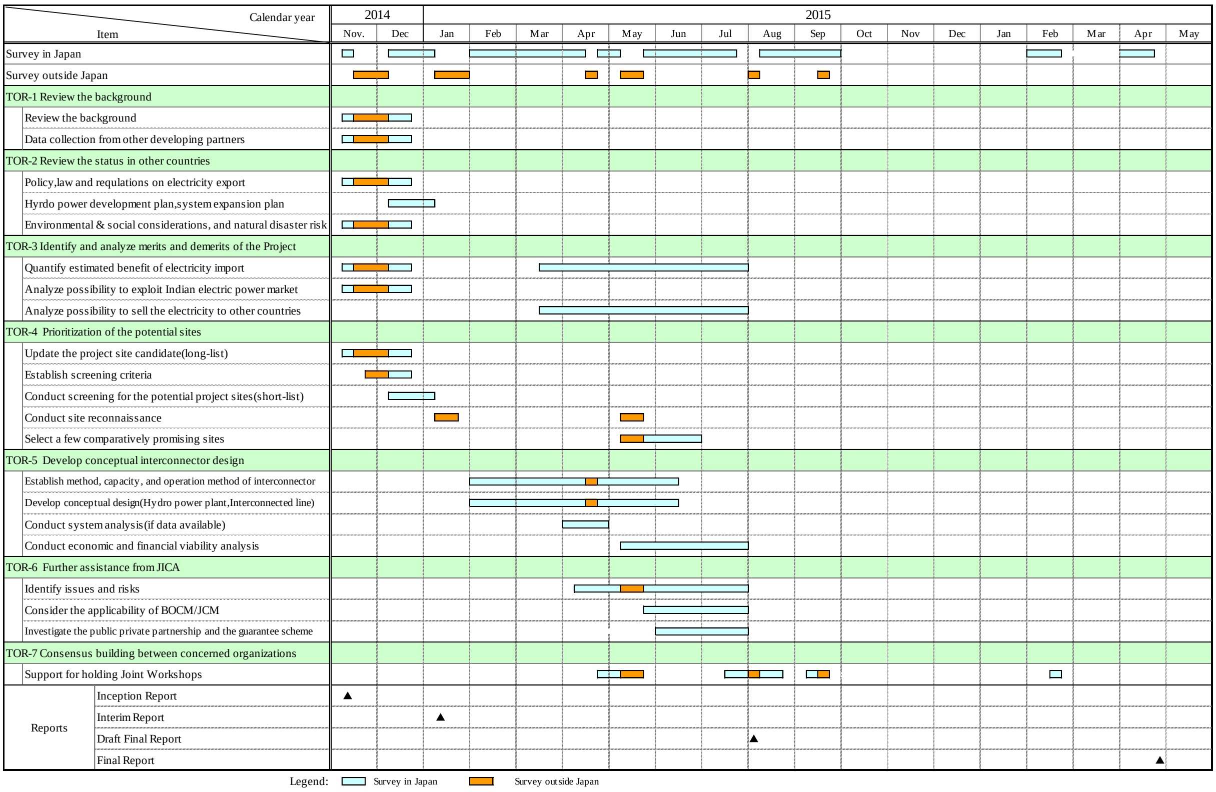
1.2.2 Area in Which to Conduct the Survey

Target area of the Survey is a region covering Bangladesh, Bhutan, Nepal, Myanmar (Desk-top study only) and India (North East States and West Bengal).

1.2.3 Work Procedure and Content

The work for this Survey starts from November 2014 and ends in May 2016, taking about 19 months. The following table shows the major work plan.

Table 1-1 Work Procedure and Content



(Source: JICA Survey Team)

1.3 Work Practice Method

1.3.1 Survey Division and Work Contents

(1) Review the background
- Review the overall policy of energy and power sector, and the policy on energy diversification in Bangladesh
- Review the policies and activities of other developing partners
- Review the interconnection cooperation policies of the SAARC region
- Review laws and regulations related to electricity import/export

(2) Review the status in other countries
- Review the policy on electricity export to Bangladesh
- Review the status of Politics, natural environment, and economic industrial structure
- Review laws and regulations related to electricity import/export
- Review the development Plan (Hydro power development plan, system expansion plan)
- Financing plan, environmental & social considerations, and natural disaster risk for hydro power development

(3) Identify and analyze merits and demerits of the Project
- Review the policy on electricity import in Bangladesh
- Quantify estimated benefit of electricity import
- Analyze possibility to exploit Indian electric power market
- Analyze possibility to sell the electricity to other countries

(4) Prioritization of the potential project sites
- Update the project site candidates (long-list)
- Establish Screening Criteria
- Conduct screening for the potential project sites (short list)
- Confirm the relevant physical, biological, and socio-economic conditions
- Select a few comparatively promising sites

(5) Develop conceptual interconnector design
- Establish method, capacity, and operation method of interconnector
- Develop conceptual design (Hydro power plant, Interconnected line)
- Conduct system analysis (if data available)
- Conduct economic and financial viability analysis
- Asses and compare the environmental and social impacts to be brought by the implementation of the potential projects

(6) Further assistance from JICA
- Identify issues and risks
- Consider the applicability of BOCM/JCM
- Investigate the public private partnership and the guarantee scheme

(7) Consensus building between concerned organizations
- Support for holding Joint Workshops

1.3.2 Flow of Work Practice

Figure 1-1 shows the basic work flow.

TOR-1 Review the background

- Review the overall policy of energy and power sector, and the policy on energy diversification in Bangladesh
- Review the policies and activities of other developing partners
- Review the interconnection cooperation policies of the SAARC region
- Review laws and regulations related to electricity import/export

TOR-2 Review the status in other countries

- Review the policy on electricity export to Bangladesh
- Review the status of Politics, natural environment, and economic industrial structure
- Review laws and regulations related to electricity import/export
- Review the development Plan (Hydro power development plan, system expansion plan)
- Financing plan, environmental & social considerations, and natural disaster risk for hydro power development

TOR-3 Identify and analyze merits and demerits of the Project

- Review the policy on electricity import in Bangladesh
- Quantify estimated benefit of electricity import
- Analyze possibility to exploit Indian electric power market
- Analyze possibility to sell the electricity to other countries

TOR-4 Prioritization of the potential project sites

- Update the project site candidates (long-list)
- Establish Screening Criteria
- Conduct screening for the potential project sites (short list)
- Conduct site reconnaissance
- Confirm the relevant physical, biological, and socio-economic conditions
- Select a few comparatively promising sites

TOR-5 Develop conceptual interconnector design

- Establish method, capacity, and operation method of interconnector
- Develop conceptual design (Hydro power plant, Interconnected line)
- Conduct system analysis (if data available)
- Conduct economic and financial viability analysis
- Asses and compare the environmental and social impacts to be brought by the implementation of the potential projects

TOR-6 Further assistance from JICA

- Identify issues and risks
- Consider the applicability of BOCM/JCM
- Investigate the public private partnership and the guarantee scheme

TOR-7 Consensus building between concerned organizations

- Support for holding Joint Workshops

(Source: JICA Survey Team)

Figure 1-1 Basic Work flow (TOR correlation chart)

1.4 Implementation Structure of Survey and Survey Achievements

1.4.1 Conducting Organizations of the Partner Country

- Power Division, Ministry of Power, Energy and Mineral Resources: MOPEMR
- Steering Committee Members:

1. Golam Kibria, Director, IPP Cell-1, BPDB
2. Md. Shafiqul Islam, Asst. Chief, Power Division
3. Arun Kumar Saha, SE, Planning, PGCB
4. Masum-Al-Beruni, MD, PGCB
5. Pronab Kumar Ghosh, Deputy Secretary, EMRD
6. SK. Md. Abdul Ahad, Joint Chief, Power Division
7. Mohammad Hossain, DG, Power Cell
8. Md. Anwar Hossain, Joint Secretary, Power Division
9. Ahmad Kaikaus, Addl. Secretary, Power Division

1.4.2 Composition of JICA Survey Team

Figure 1-2 shows the composition of the JICA Survey Team.

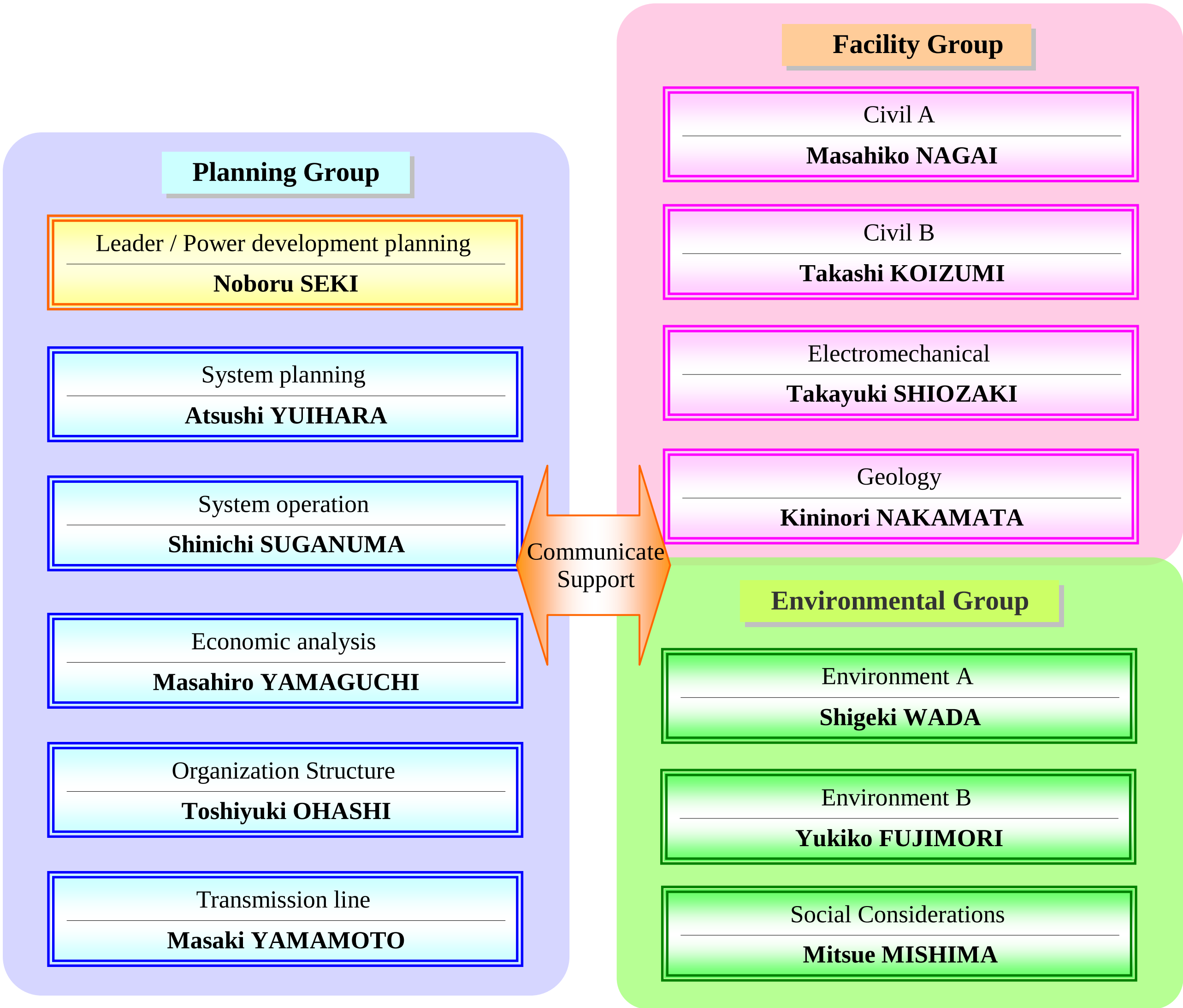


Figure 1-2 JICA Survey Team Composition

1.4.3 Work Allocation of JICA Survey Team

- Leader/Power development planning：Noboru SEKI
- System planning：Atsushi YUIHARA
- System operation：Shinichi SUGANUMA
- Civil A：Masahiko NAGAI
- Civil B：Takashi KOIZUMI
- Electromechanical：Takayuki SHIOZAKI
- Economic analysis：Masahiro YAMAGUCHI
- Geology：Kiminori NAKAMATA
- Environment A：Shigeki WADA
- Environment B：Yukiko FUJIMORI
- Social Considerations：Mitsue MISHIMA
- Organization Structure：Toshiyuki OHASHI
- Transmission line：Masaki YAMAMOTO

1.4.4 Survey achievements

The first site survey for Information Collection (November 15 to December 4 2014) was held for twenty days including travel time. For India (Shillong, Kolkata) and Nepal, the survey was done in groups. Its details are as follows.

Table 1-2 Activities during the First Site Survey for Information Collection

Countries for the Survey (Cities to Visit)	No. of Days (Including travel time)	Activities
Bangladesh (Dhaka)	6 days	■ Discussion with JICA Bangladesh Office ■ Explanation on Inception Report ■ Interview Survey with Steering Committee ■ Interview Survey with Power Grid Company of Bangladesh Limited
India (Delhi, Shillong, Kolkata)	10 days	■ Discussion with JICA India Office ■ Explanation on Inception Report ■ Interview Survey with the governmental organizations (Ministry of Power/Delhi) ■ Interview Survey with Power Grid Company and India Limited (Delhi) ■ Interview Survey with Meghalaya Energy Corporation Limited (Shillong) ■ Interview Survey with Eastern Regional Load Dispatch Center (Kolkata)
Nepal (Kathmandu)	3 days	■ Discussion with JICA Nepal Office ■ Explanation on Inception Report ■ Interview Survey with the governmental organizations (Ministry of Energy) ■ Interview Survey with Asia Development Bank ■ Interview Survey with Nepal Electricity Authority

Bhutan (Thimphu)	4 days	■ Discussion with JICA Bhutan Office ■ Explanation on Inception Report ■ Interview Survey with the governmental organizations (Ministry of Economic Affairs) ■ Interview Survey with Bhutan Power Corporation ■ Interview Survey with Druk Green Power Corporation

The second site survey for Information Collection (January 12 to January 27 2015) was undertaken for sixteen days including travel time. For India (Delhi, Guwahati and Shillong), Bhutan and Nepal, the survey was carried out in three groups. Its details are as follows.

Table 1-3 Activities during the Second Site Survey for Information Collection

Countries for the Survey (Cities to Visit)	No. of Days (Including travel time)	Activities
India (Delhi, Guwahati, and Shillong)	7 days	■ Discussion with JICA India Office ■ Explanation on Interim Report ■ Interview Survey with the governmental organizations (Ministry of Power/Delhi, Central Electricity Regulatory Commission/Delhi) ■ Interview Survey with power trading companies (PTC India and NVVN/Delhi) and a power market operator (IEX/Delhi) ■ Interview Survey with Meghalaya Energy Corporation Limited (Shillong) ■ Site visits to a hydropower and under DPR sites (Myntdu Leshka Stage-1/Myntdu Leshka Stage-2/Umngot and Nongkohlait)
Nepal (Kathmandu)	5 days	■ Discussion with JICA Nepal Office ■ Explanation on Interim Report ■ Interview Survey with the governmental organizations (Ministry of Energy) ■ Interview Survey with Nepal Electricity Authority ■ Site visits to a hydropower and substation construction sites (Khulekani-3 HPP and Hateuda S/S)
Bhutan (Thimphu)	8 days	■ Discussion with JICA Bhutan Office ■ Explanation on Inception Report ■ Interview Survey with the governmental organizations (Ministry of Economic Affairs) ■ Interview Survey with Bhutan Power Corporation ■ Interview Survey with Druk Green Power Corporation ■ Site visits to a hydropower and transmission line construction sites (Punatsangchhu-1,2) ■ Site visits to Pre-F/S completed sites (Gamri-1,2 and Nyera Amari-1,2)

The three site survey for Information Collection (April 11 to April 18 2015) was undertaken for eight days including travel time. For Bangladesh, the survey was done in groups. Its details are as follows.

Table 1-4 Activities during the Third Site Survey for Information Collection

Countries for the Survey (Cities to Visit)	No. of Days (Including travel time)	Activities
Bangladesh (Dhaka)	8 days	■ Discussion with JICA Bangladesh Office ■ Interview Survey with Steering Committee ■ Interview Survey with National Load Despatch Center

The four site survey for Information Collection (May 11 to May 27 2015) was undertaken for seventeen days including travel time. For Bangladesh, India (Delhi, Guwahati and Shillong), and Bhutan, the survey was carried out in two groups. Its details are as follows.

Table 1-5 Activities during the Fourth Site Survey for Information Collection

Countries for the Survey (Cities to Visit)	No. of Days (Including travel time)	Activities
Bangladesh (Dhaka)	2 days	■ Discussion with JICA Bangladesh Office ■ Arrive at Dhaka from Bhutan
India (Delhi, Guwahati, and Shillong)	7 days	■ Discussion with JICA India Office ■ Interview Survey with Meghalaya Energy Corporation Limited (Shillong) ■ Site visits to under DPR and Pre-F/S completed sites (Umngot and Nongkohlait)
Bhutan (Thimphu)	11 days	■ Discussion with JICA Bhutan Office ■ Interview Survey with the governmental organizations (Ministry of Economic Affairs) ■ Interview Survey with National Environment Commission ■ Courtesy Call to Minister of MOEA (Ministry of Economic Affairs) ■ Technical Discussion Meeting with Bangladesh delegation ■ Site visits to hydropower construction sites (Punatsangchhu-1, 2) and existing Hydropower Plant (Chhukha) ■ Site visits to sites (Kuri-1 and Nyera Amari-1, 2)

Chapter 2 Status of each Country's Power Sector

2.1 Bangladesh

2.1.1 Energy Policy

(1) Energy Balance in Bangladesh

Table 2-1 shows the primary energy balance for 2012. Of the total amount of energy supply – 33.172 Gtoe[1], natural-gas is 18.34 Gtoe (55.3%), biofuels-and-waste is 8.89 Gtoe (26.8%) and coal, crude-oil and oil-products are 5.88 Gtoe (17.8%). "Hydro" is only 0.76 Gtoe (less than 0.2%).

All of the natural-gas and biofuels-and-waste supplies (27.228 Gtoe: 82.1% of total energy supply) can be covered by domestic production or stock, but most of the coal, crude-oil and oil-products (5.622 Gtoe; 17.0% of total energy supply) are imported.

At present, the natural gas supply in Bangladesh can be covered by domestic production, as mentioned above. However, according to the "Annual Report 2012" of Petrobangla, annual production is increasing year by year, and the cumulative production up to December 2012 had reached 10.92 TCF[2.] Proved Recoverable Reserve in Bangladesh is 20.70 TCF and Probable Recoverable Reserve is 6.34 TCF. Therefore, Remaining Reserve is 16.12 TCF.

As shown in Figure 2-1, the team of PSMP 2010 estimates that the natural gas annual production will reach its peak in 2017 and then gradually decrease in the future. Therefore, it can be said that diversification of the energy sources in Bangladesh is an urgent need.

Table 2-1 Energy Balance in Bangladesh for 2012

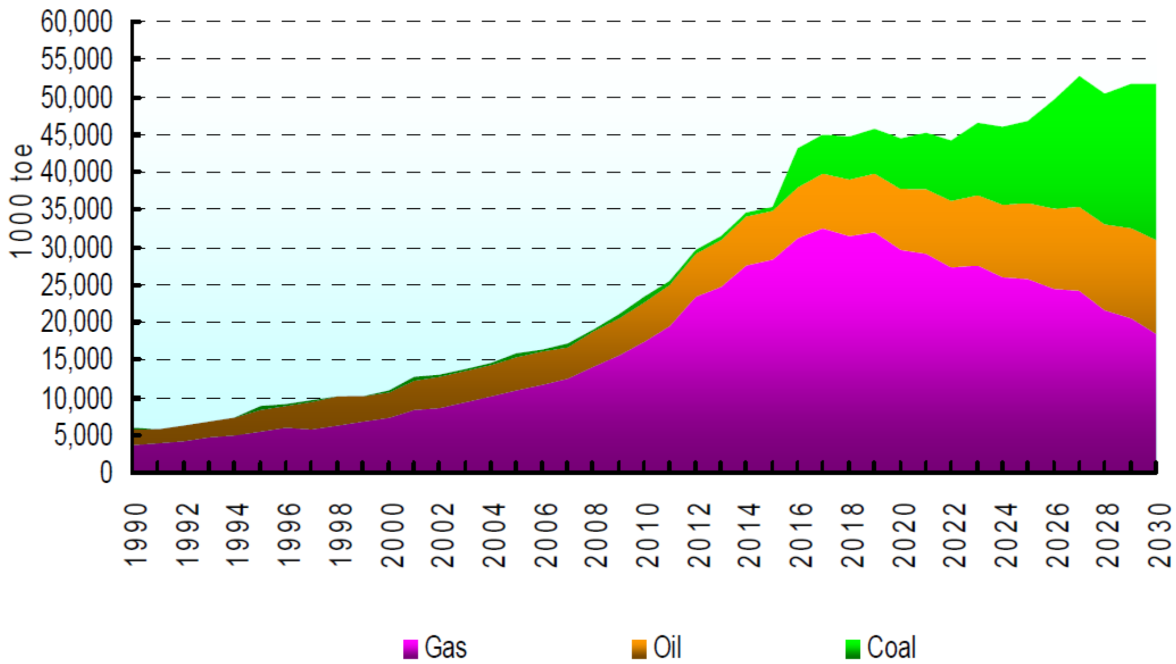
UNIT: ktoe

Item	Coal*	Crude oil*	Oil products	Natural gas	Hydro	Biofuels and waste	Electricity	Total**
Production	417	239		17574	67	8890		27187
Imports	500	1275	3848					5622
Exports		-11	-123					-134
International marine bunkers***			-87					-87
International aviation bunkers***			-332					-332
Stock changes	-14	-117	283	764				916
TPES	**903**	**1386**	**3588**	**18338**	**67**	**8890**	**0**	**33172**
Transfers		-96	100					4
Statistical differences	-1		142				236	376
Electricity plants	-224		-1065	-10228	-67		4217	-7367
Oil refineries		-1290	1266					-24
Energy industry own use	-11		-70				-237	-319
Losses				-473			-498	-970
Total final consumption	**666**	**0**	**3960**	**7637**	**0**	**8890**	**3719**	**24872**
Industry	666		157	3036		8890	2039	5898
Transport			2138	911				3049
Residential			428	2091			1273	12682
Commercial and public services				202			222	424
Agriculture / forestry			1110	18			125	1253
Non-specified							60	60
Non-energy use	0	0	127	1380	0	0	0	1507

* The column for coal also includes peat and oil shale where relevant; that of crude oil includes crude oil, NGL, refinery feedstocks, additives and other hydrocarbons.
** Totals may not add up due to rounding.
*** International marine and aviation bunkers are included in transport for world totals.

(Source: IEA (International Energy Agency) Website)

1 toe : tons of oil equivalent on a net calorific value basis
2 TCF: trillion cubit feet



(Source: PSMP 2010)

Figure 2-1 Trend and Forecast of Primary Energy Supply in Bangladesh

Energy source for power supply in 2012 is shown in Table 2-2. Natural gas generation amounts to about 85% of the total power generation. So, it can also be said that diversification of energy sources for electricity is urgently required.

Table 2-2 Primary Energy for the Electricity in Bangladesh (2012)

Production from:	Unit: GWh
- coal	883
- oil	5652
- gas	41727
- hydro	777
Total production	**49039**
Imports	0
Exports	0
Domestic supply	**49039**
Statistical differences	2741
Energy industry own use*	**2756**
Losses	5785
Final consumption	**43239**
Industry	23709
Residential	14801
Commercial and public services	2581
Agriculture / forestry	1455
Other non-specified	693

* Energy industry own use includes own use by plants.

(Source: IEA (International Energy Agency) Website)

It should be noted that in the statistics of the 2012 stage, there is no record of power import or export. As shown in Section 3.2.1, construction of 400kV HVDC interconnection between India - Bangladesh (rated capacity: 500MW) had been completed on September 2013, and power imports from India have been started since then.

Actual data of power imports are shown in Table 2-3. The cumulative imported power since the start is 3300.18 GWh, and it can not be said to be large, compared with the total power production in 2012. For the diversification of power sources, further enhancement of international connection is desired.

Table 2-3 Electricity Imports from India via Interconnection between Bheramara and Baharampur

Unit: GWh

2013		2014									
Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
96.63	277.85	320.32	311.45	330.98	271.94	279.21	280.14	289.62	263.37	268.85	309.82

(Source: PGCB Monthly Reports)

(2) Power import and export policy (the result of Steering Committee)
On October 2014, a SAARC regional meeting was held, and the hydro power development potential in the region was discussed. The potential of hydro power is huge, at around 350 GW. Most political leaders of the region agree on hydro-power cooperation.

Political leaders in Bangladesh have plans for the expansion of cross border energy imports with hydro to the extent of 20 GW, and have already started to conduct feasibility studies for interconnection between Purnea (India) and Barapukuria, Aliduarpur (India) and Bogra.
GMR (private power producer) is developing a 1500MW hydro power station in Nepal (2020). They have agreed to sell 500MW to Bangladesh after 2020.

In addition, power imports of 100MW from the Palatana power plant in India are also being specifically promoted, with interconnection plan between Comilla and the Palatana region. In this plan, a load of 100MW in Bangladesh is disconnected from their power system, and the power for this load is injected from the Indian power system via interconnection, possibly for system stability reasons.

2.1.2 Entities for Electric Power Development Policy, Planning and Promotion

(1) The Ministry of Power, Energy and Mineral Resources (MOPEMR) and Power Cell (PC)
MOPEMR is composed of "Energy and Mineral Resources Division" and "Power Division".

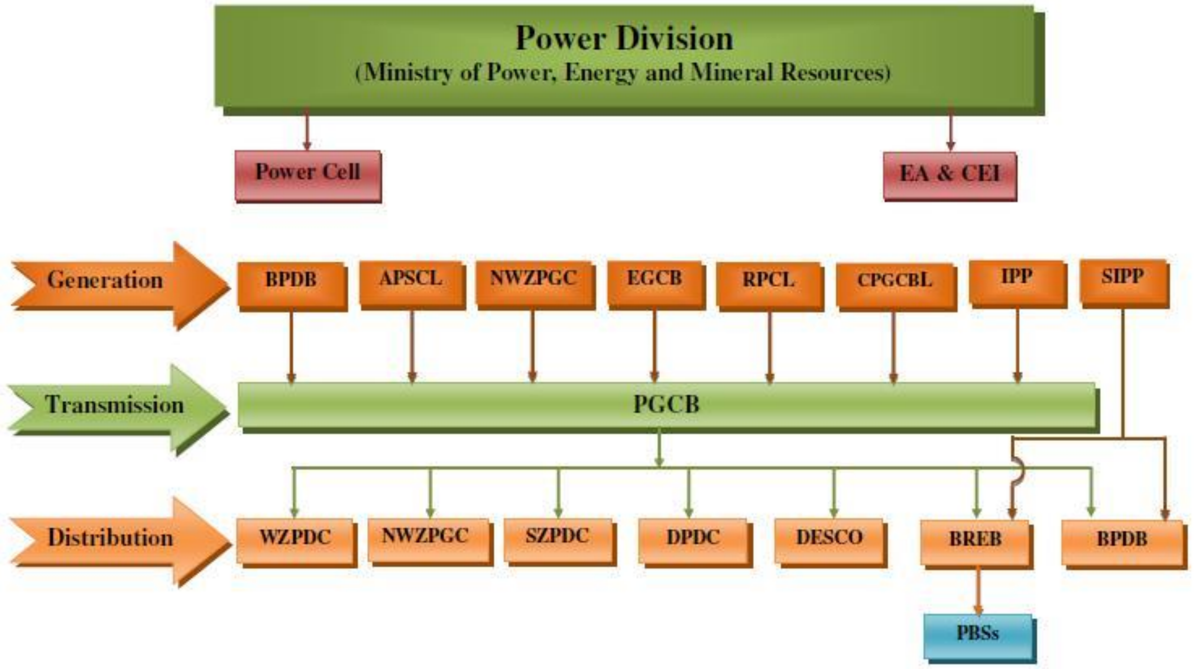
The Energy and Mineral Resources Division is responsible for achieving energy security for the country through the supply of sustainable energy services for all at affordable prices and the exploitation of mineral resources in an environmentally sustainable manner. This division mainly deals with administrative and financial matters or policies relating to petroleum, natural gas, mineral resources, geological survey, etc.

The Power Division is responsible for achieving the provision of affordable and reliable electricity supply for all by the year 2021 through improvements in the generation, transmission and distribution systems.
Its Major Functions are as follows:

- All activities related to power generation, transmission and distribution;
- Manage all matters and policies related to the Power sector;
- Expand, rehabilitate and modernize power generation, transmission and distribution services in line with the increasing national demand and prepare action plans and programs accordingly;
- Encourage private and joint venture investment in the Power sector in addition to the government investment;

- Improve the standard of living of the rural poor through rural electrification and the introduction of renewable energy;
- Monitor revenue earnings and commercial activities of the utilities ;
- Promotion of renewable energy and energy efficiency through formulation of policy/regulations, different incentive mechanism and R&D.

The Power Division is supported by a number of organizations, related to generation, transmission and distribution, to implement its mandate. The organizational linkage is as shown in Figure 2-2.



(Source: Web site of Power Division)

Figure 2-2 Organizational Structure of the Power Division

In 1995, Power Cell (PC) was created by the government under the Power Division in order to carry forward the Power Sector reform activities of the government of Bangladesh. The objectives of the reform program can be stated as (not limited to):

- To develop an implementable plan of reform program
- To implement specific programs to achieve desirable performance improvements, consumer satisfaction and viability of the sector
- To help the utilities to achieve accelerated development of the sector with optimum utilization of resources
- To develop a strategy for the corporatization of different entities
- To structure a financial & business plan for the existing & emerging entities
- To develop a strategy for distribution area demarcation & rationalization of the utilities
- To develop an HR/D plan for the existing & emerging entities
- To develop & implement a central, well-designed MIS & IT system for the power sector
- To build in-house capacity for system improvement & sector efficiency in formulating the tariff calculation and cash flow studies
- To develop the power sector master plan incorporating the updated data
- To establish a communication system among the sector's utilities

(2) Bangladesh Energy Regulatory Commission (BERC)

BERC was established on March 13, 2003 through a legislative Act of the Government of Bangladesh. The commission became effective on April 27, 2004 with the appointment of two of the five member commissions, including the chairman. The chairman was appointed on June 4, 2005.

The commission has the mandate to regulate Electricity, Gas and Petroleum products for the whole of Bangladesh, in order to create an enabling environment; an efficient, well-managed and sustainable energy sector in Bangladesh for providing energy at a just & reasonable cost; and the protection of consumers' interest & satisfaction through fair practice.

The functions of BERC (Mandated by Law) are as follows:

- Issue, cancel, amend and determine conditions of licenses, exemption of licenses and determine the conditions to be followed by such exempted persons.
- Help ensure efficient use and quality services, determine tariffs and safety enhancements for electricity generation and the transmission, marketing, supply, storage and distribution of energy.
- Approve schemes on the basis of overall programs of the licensee and take decisions taking into consideration the load forecast and financial status.
- Extend co-operation and advice to the Government, if necessary, regarding electricity generation, and the transmission, marketing, supply, distribution and storage of energy.
- Encourage the creation of a congenial atmosphere to promote competition amongst the licensees.
- Ensure control of environmental energy standards under existing laws.
- Ensure appropriate remedies for consumer disputes, dishonest business practices or monopolies.
- Resolve disputes between licensees and between licensees and consumers, and refer to arbitration if necessary.
- Develop a uniform methodology of accounting for all licensees to help ensure performance rating on a fair platform.
- Collect, review, maintain & publish statistics of energy.
- Frame codes and standards and make enforcement of those compulsory to ensure quality of services.
- Determine efficiency and standards of the machinery & appliances using energy and ensure through energy audits the verification, monitoring, analysis of the energy data and economic use and enhancement of efficiency on use of energy.
- Perform any incidental functions if considered appropriate by the Commission for fulfilling the objectives of the Act.

(3) Bangladesh Power Development Board (BPDB)

BPDB is a statutory body created on May 1, 1972, by presidential Order No. 59 after the bifurcation of the erstwhile Bangladesh Water and Power Development Authority.

As part of reform and restructuring a number of Generation and Distribution companies have been created. The subsidiaries of BPDB are:

- Ashuganj Power Station Company Ltd. (APSCL)
- Electricity Generation Company of Bangladesh (EGCB)
- North West Power Generation Company Ltd. (NWPGCL)
- West Zone Power Distribution Company Ltd. (WZPDCL)

The BPDB is responsible for the major portion of generation and distribution of electricity, mainly in urban areas except Dhaka and the West Zone of the country. The Board is under the Power Division of the Ministry of Power, Energy and Mineral Resources, Government of Bangladesh.

BPDB's vision is to provide quality and reliable electricity to the people of Bangladesh for the desired economic, social and human development of the country, undertaking institutional and structural reforms leading to the creation of an organization of international standard.

The mission of BPDB is as follows:

- To deliver quality electricity at reasonable and affordable prices with professional service excellence.
- To make electricity available to all citizens on demand by the year 2021.
- To provide specialized skilled services in operation & maintenance with outstanding performance in Generation, Transmission and Distribution for promoting competition among various power-sector entities.
- To follow international standards and adopt modern technology and practices in power generation activities.
- To ensure improved and satisfactory services for consumers.
- To develop a new mindset for all of its employees congruent with the corporate culture.
- To reach self sufficiency by increasing its income and reducing expenditure through efficiency improvement and diversification of activities.

(4) Power Grid Company of Bangladesh (PGCB)

PGCB was created under the restructuring process of the Power Sector in Bangladesh with the objective of bringing about a commercial environment including an increase in efficiency, establishment of accountability and dynamism in accomplishing its objectives. PGCB was incorporated in November 1996 with an authorized capital of Tk.10 billion. It was entrusted with the responsibility to own the national power grid and to operate and expand the same with efficiency. Pursuant to the Government decision to transfer transmission assets to PGCB from Bangladesh Power Development Board (BPDB) and Dhaka Electric Supply Authority (DESA), PGCB completed the taking over of all the transmission assets on December 31, 2002. Since then, PGCB has been operating these efficiently and effectively.

PGCB is a public limited company, incorporated through sponsorship of the chairman, BPDB and its six members. (76.25% ownership by BPDB & 23.75% by general public)

The mission of PGCB is the efficient and effective management of the national power grid for the reliable and quality transmission of electricity through the country.

The activities of PGCB are categorized as follows:

- Operation & maintenance of grid sub-station and transmission line
- Load despatching
- Operation & Maintenance of SCADA System.
- Operation & maintenance of communication system.
- Protection, relay co-ordination of Transmission System.
- Design & evaluation.
- Transmission network planning.
- Implementation of development projects.

2.1.3 Power Supply and Demand

(1) Current Status

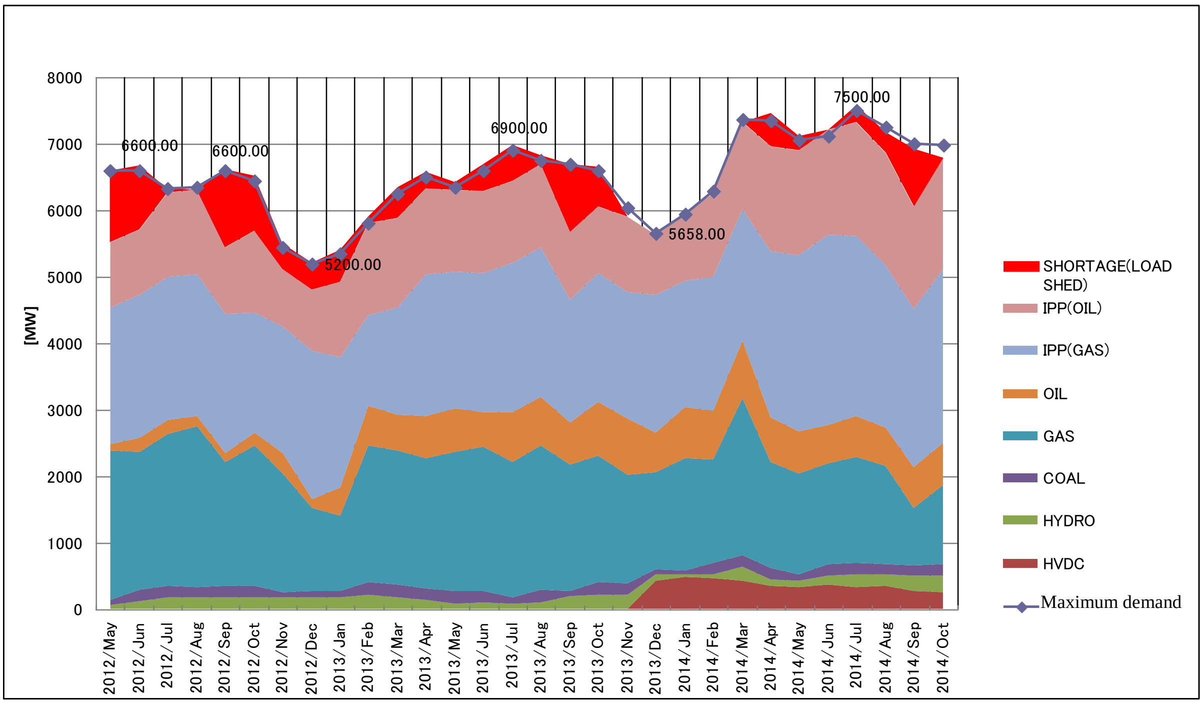
Table 2-4 shows the trend of installed capacity, actual output power, maximum demand and load shedding. Despite efforts to enhance the power capacity year by year, installation can not keep up with the growing demand, which results in forced load shedding. The yearly maximum of forced outages recorded a peak of 1459MW in 2009-2010. Still, more than 1,000MW of load is cut off even now.

Table 2-4 Installed Capacity, Present Capacity, Maximum Demand, Maximum Peak Generation and Load Shedding

Year	Installed capacity (MW)[1]	Present Capacity (Derated) (MW)[2]	Maximum Demand (MW)[3]	Maximum Peak Generation (MW)	Maximum Load Shedding (MW)
2000-01	4,005	3,033	3,394	3,033	663
2001-02	4,230	3,218	3,659	3,218	367
2002-03	4,680	3,428	3,947	3,428	468
2003-04	4,680	3,592	4,259	3,592	694
2004-05	4,995	3,721	4,597	3,721	770
2005-06	5,245	3,782	4,693	3,782	1,312
2006-07	5,202	3,718	5,112	3,718	1,345
2007-08	5,201	4,130	5,569	4,130	1,049
2008-09	5,719	5,166	6,066	4,162	1,269
2009-10	5,823	5,271	6,454	4,606	1,459
2010-11	7,264	6,639	6,765	4,890	1,335
2011-12	8,716	8,100	7,518	6,066	1,058
2012-13	9,151	8,537	8,349	6,434	1,048

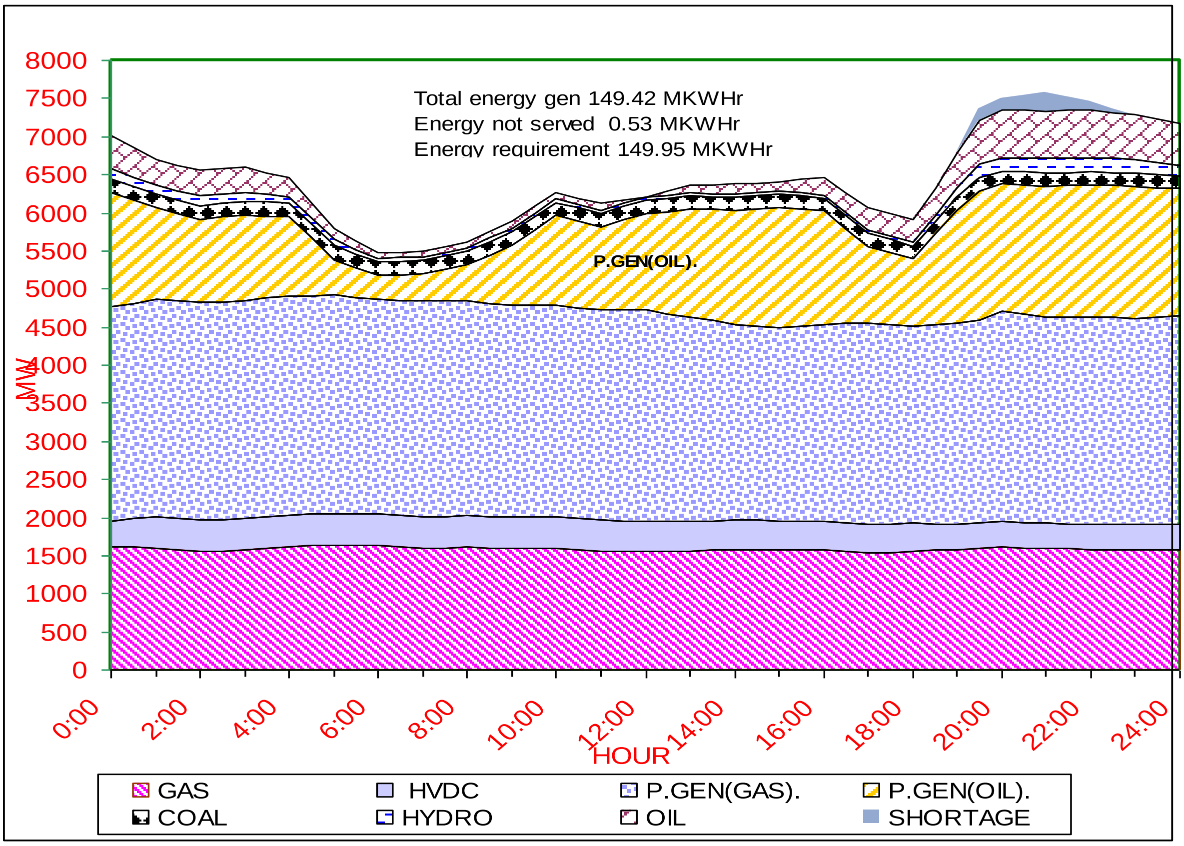
Note: 1 Installed capacity is as of June of the year
2 Present Capacity (Derated) is the Maximum available generation capacity at present
3 Maximum Demand is shown as per power system master plan 2010

(Source: BPDB Annual Report 2012-2013)



(Source: PGCB Monthly and Daily Reports)

Figure 2-3 Trend of Monthly Maximum Power Demand in Bangladesh



(Source: PGCB Daily Reports)

Figure 2-4 Daily Load Curve in Bangladesh (14th/Jul./ 2014)

Figure 2-3 shows the trend of monthly maximum power demand and power source. The main features are as follows:

- Yearly maximum demand tends to be recorded in July every year, and the least off-peak demand is in February.
- Proportion of natural gas generation is overwhelmingly large. On the other hand, coal and hydro are very small.
- Previously, load shedding was conducted throughout the year. However, since November 2013, when power imports from India were initiated, the frequency of load shedding in the off-peak season appears to have been eased.

Figure 2-4 shows the daily load curve and power source on July 14, 2014. At around 21:00, a maximum power demand of 7500MW was recorded. The main features are as follows:

- Daily peak demand tends to be recorded in the evening, and, generally, demand during the night time is higher than that of the day time.
- Load shedding is still imposed at around the peak time.
- Coal, gas thermal and imported power are allocated for the base load. Oil thermal Power is for peak load and adjustment of supply and demand.

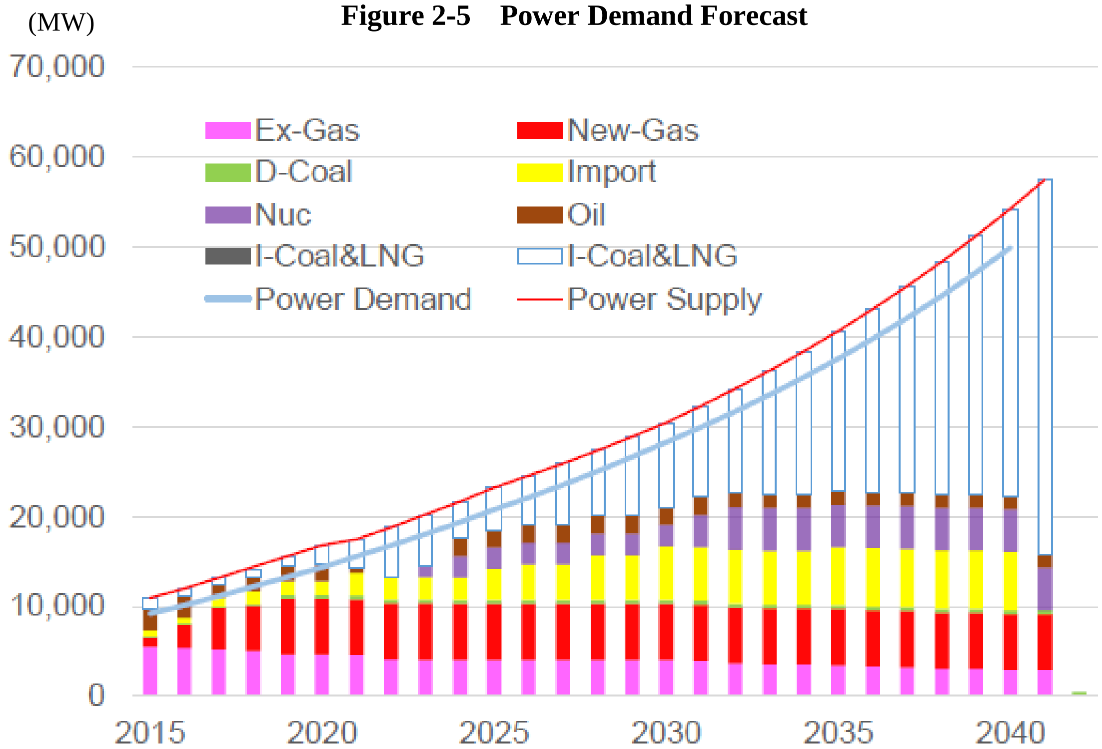
(2) In the Future

Figure 2-5 shows the demand forecast up to 2040 in PSMP2015. The PSMP2015 team is estimating that the future electricity demand combining reserve margin – equal to required supply – will reach to 18,000 MW in 2020, 23,000 MW in 2025, and 55,000 MW in 2040.

And, as shown in Figure 2-6, optimum combination of import Coal, LNG and Oil will be decided through further scrutiny with consideration of 3E Concept.

(Source: PSMP 2015 #2nd steering committee report)

Figure 2-5 Power Demand Forecast

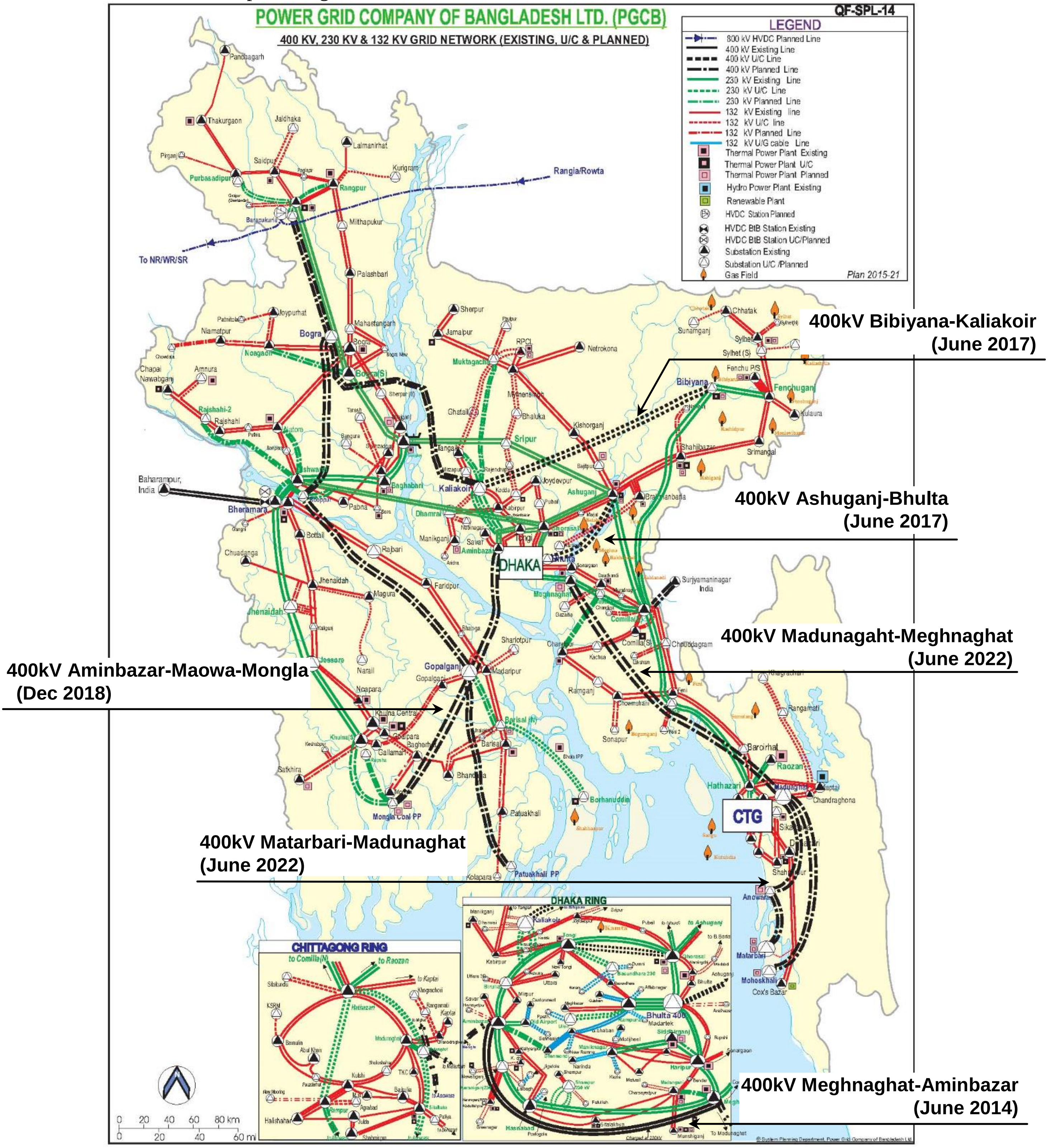


(Source: PSMP2015 #2nd steering committee report)

Figure 2-6 Tentative Power Development Plan up to 2040

2.1.4 Bangladesh Power Grid

The Power Grid Map of Bangladesh is shown below.



(Source: PGCB Home Page)

Figure 2-7 Power Grid Map of Bangladesh (Plan 2015-21)

The 400kV transmission line expansion plan responding to the power development plan is progressing steadily.

Table 2-5 400kV Transmission Line Expansion Plan

400kV Transmission Line				
	Name of Lines	Lenth in Route (km)	No of Ckt.	Project Completion
Completed	Meghnaghat-Aminbazar	54	Double	June '2014
On going	Bibiyana-Kaliakoir	168.64	Double	June '2017 (Revised)
	Ashuganj-Bhulta	70	Double	June '2017
Upcoming	Matarbari-Madunaghat	92	Double	June '2022
	Madunagaht - Meghnaghat	214	Double	June '2022
	Aminbazar-Maowa-Mongla	164.6	Double	Dec '2018
Total		763.24		

(Source: PGCB Home Page)

The bulk power system is mainly composed of 230kV and 132kV. The length in circuit of the transmission line reaches 9,492km in total, with 165km on 400kV, 3,044km on 230kV, and 6,283km on 132kV.

The outline of existing transmission lines and substations of 400kV and 275kV is shown as follows.

Table 2-6 Transmission Line List (existing)

400kV Transmission Line

Sl. No.	Name of Lines	Lenth in Route (km)	Lenth in Ckt. (km)	No. of Ckt.	Conductor	
					Name	Size
1	HVDC Bheramara-Baharampur	27.35	54.7	Double	Twin Finch	1113 MCM
2	Aminbazar-Meghnaghat	55	110	Double	Quad Egret	636 MCM
Total		82.35	164.7			

230kV Transmission Line

Sl. No.	Name of Lines	Lenth in Route (km)	Lenth in Ckt. (km)	No. of Ckt.	Conductor	
					Name	Size
1	Ghorasal-Ishurdi (1st EWI)	175	350	Double	Mallard	795 MCM
2	Tongi - Ghorasal	27	54	Double	Mallard	795 MCM
3	Ghorasal - Ashuganj	44	88	Double	Mallard	795 MCM
4	Raojan - Hathazari	22.5	45	Double	Twin 300 sq.mm	
5	Ashuganj - Comilla North	79	158	Double	Finch	1113 MCM
6	Ghorasal - Rampura	50	100	Double	Twin Mallard	2x795 MCM
7	Rampura - Haripur	22	44	Double	Twin Mallard	2x795 MCM
8	Haripur - Meghnaghat	12.5	25	Double	Twin Mallard	2x795 MCM
9	Meghnaghat - Hasnabad	24.5	49	Double	Twin Mallard	2x795 MCM
10	Comilla North - Hathazari	151	302	Double	Finch	1113 MCM
11	AES, Haripur - Haripur	2.4	4.8	Double	Finch	1113 MCM
12	Comilla North - Meghnaghat	58	116	Double	Twin Mallard	2x795 MCM
13	Tongi-Aminbazar	25.2	50.4	Double	Twin AAAC	37/4.176 mm.
14	Aminbazar-Hasnabad	21.5	43	Double	Twin AAAC	37/4.176 mm.
15	Siddhirganj 210 MW P/S - Haripur	1.5	1.5	Single	ACSR	600 sq. mm.
16	Ashuganj - Sirajganj (2nd EWI)	144	288	Double	Twin AAAC	37/4.176 mm.
17	Khulna-Bheramara HVDC	176.5	353	Double	Twin AAAC	37/4.176 mm.
18	Bheramara HVDC- Ishurdi	10.1	20.2	Double	Twin AAAC	37/4.176 mm.
19	Bogra-Barapukuria	106	212	Double	Twin AAAC	37/4.176 mm.
20	Sirajganj-Bogra	72.5	145	Double	Twin AAAC	37/4.176 mm.
21	Ishurdi-Baghabari	55	110	Double	Twin AAAC	37/4.176 mm.
22	Baghabari-Sirajganj	38	76	Double	Twin AAAC	37/4.176 mm.
23	Fenchuganj-Bibiyana	33.185	66.37	Double	Twin Mallard	2x795 MCM
24	Bibiyana-Comilla(N)	153.55	306	Double	Twin Mallard	2x795 MCM
25	Aminbazar-Old Airport (O/H)	3.575	7.15	Double	Twin Mallard	2x795 MCM
26	Aminbazar-Old Airport (U/G)	4.013	8.026	Double	XLPE	2000 sq. mm.
27	Siddhirganj-Maniknagar	11	22	Double	Twin Mallard	2x795 MCM
Total		1523.523	3044.446			

(Source: PGCB Home Page)

$MCM=0.50671mm^2$

Table 2-7 Substation List (existing)

400kV Substations				
Sl. No.	Name of Grid Substation	Transformer Capacity (MVA)	Total Capacity (MVA)	GMD
1	Bheramara HVDC Back to Back Station	1 x 500	500	HVDC

230kV/132kV Substations				
Sl. No.	Name of Grid Substation	Transformer Capacity (MVA)	Total Capacity (MVA)	GMD
1	Meghnaghat Switching			Dhaka(East)
2	Rampura	3x225(10x75)	675	Dhaka(Center)
3	Haripur	3x225(10x75)	675	Dhaka(East)
4	Maniknagar	2x300	600	Dhaka(Center)
5	Hasnabad	3x225(10x75)	675	Dhaka(South)
6	Siddhirganj	2x300	600	Dhaka(East)
7	Tongi	3x225(10x75)	675	Dhaka(North)
8	Agargaon	2x300	600	Dhaka(North-West)
9	Aminbazar	3x225	675	Dhaka(North-West)
10	Hathazari	4x150	600	Chittagong(North)
11	Comilla(N)	2x225	450	Comilla
12	Fenchuganj	1x300	300	Srimangal
13	Khulna(S)	2x225(7x75)	450	Khulna
14	Bogra	2x225(7x75)	450	Bogra
15	Barapukuria	2x225	450	Rangpur
16	Sirajganj (Switching)			Bogra
17	Ishwardi	3x225	675	Ishwardi
18	Baghabari	1x225(4x75)	225	Ishwardi

(Source: PGCB Home Page)

2.1.5 The Necessity and Validity of the Interconnection

As described above, domestic production of natural gas is expected to decrease in the future. So, exploration of supplemental fuel resources should be actively implemented. But it is not expedient to depend only on imported fuels or fossil fuels (such as coal or oil) as an alternative to domestic natural gas from the viewpoints of environmental or energy security.

As a short or medium term solution, there is the development of renewable energy power such as hydro, solar, wind and biomass. Among them, the development of hydro power is expected to play an important role as a stable power source.

Fortunately, there is expected to be much potential for hydro power development in neighboring countries such as Nepal, Bhutan and the northeast region of India. In addition, agreement on hydroelectric power development and the construction plan of the HVDC international tie-line for international power interchange among SAARC countries has been attained and is being vigorously promoted.

Moreover, hydro power generators have many advantages in system operational aspects compared to thermal or nuclear generators, as per the below:

- Hydro power generators do not require such a long startup time compared to other types of generators. So, they are expected to play an important role as an emergency power source upon the sudden shut off of other generators, or as a supplemental power source for unexpected demand increase. (Refer to Table 2-8)

- Hydro power generators can change their power output widely and speedily within the rated output, compared to other types. So, they are suitable for adjustment of supply – demand gap or frequency fluctuation control. (Refer to Table 2-8)
- Since hydro power generators can be effectively utilized for an adjustment corresponding to the unavoidable fluctuations of output power from wind or PV, it is possible to increase the renewable energy power supply.

However, in order to exploit the advantages described above, the generators have to be connected in synchronization with main grid.

Table 2-8 Typical Numerical Data of Start Up Time and Output Change Rate

	Start up time after 8 hours' shutdown	Output Change Rate
Hydro	3-5 min.	50-60 % / min.
Oil	3 hours	1-3 % / min.
Gas C/C	1 hour	5% / min.
Coal	4 hours	1-3 % / min.
Nuclear	5 days	Not available in Japan

(Source: JICA Survey Team)

The announced cause of a nation-wide blackout in Bangladesh, which occurred on November 1, 2014, was that the Back-to-Back, installed within the 400kV interconnection between India and Bangladesh, was suddenly shut off due to some trouble. Interchange power of about 450MW from India to Bangladesh was suddenly interrupted, causing a rapid drop of system frequency and cascading trip of generators. The system frequency was reported as having dropped temporarily to 45Hz (rated frequency is 50Hz). Therefore, combined with the information that the power demand was about 4,400MW at the time of accident, power-frequency constant of the power system can be estimated at about 1 %MW/%Hz in Bangladesh. This is significantly small compared to the constant of 2.5 - 5.0 %MW/%Hz in Japan.

Countermeasures for enhancement of the power-frequency characteristics are as below:

- Increasing the number of synchronous generators connected with electrically synchronized condition. Hydro power generators are much better to enhance the frequency stability.
- Accommodation of the function of emergency power injection or automatic frequency control to the AC/DC converting facilities.

Also, from the viewpoint of rapid recovery from nation-wide blackout, it is very important to possess various points of interconnection which can inject power from neighboring countries, or various types of generators which can start up autonomously (such as run-of-river type hydro, diesel generators, etc.).

In view of the above, the development of hydroelectric power in Bangladesh is considered to be very effective. Therefore, in this project, the JICA Survey Team will continue to conduct the hydropower potential research in neighboring countries and the development of international tie-lines.

2.2 Bhutan

2.2.1 Energy Policy

(1) National Five-Year Plan

For the 11th Five-Year Plan (2013-2018), a goal has been set to maintain a high GDP growth rate of 9-10% up to 2018. In all national five-year plans, there are overall goals to reduce poverty, and promote economic growth, while adjusting regional disparities, in particular, by the promotion of large-scale hydropower development relying greatly on national income. It can be said that power development as a national strategy has been playing a vital role, when considering the current situation whereby the expansion of power exports to India, together with the promotion of rural electrification, have been supporting economic growth.

(2) Sustainable Hydro Power Development Policy 2008

The potential hydropower capacity in the country is estimated to be approximately 30,000 MW. In 2006, the equipment capacity of hydroelectric power plants was 1,488 MW. This remained at a level of approximately 5% in the development of the entire occluded hydropower. The Plan has set a goal to aim for the promotion of hydropower development to a minimum level of 10,000 MW by 2020.

In particular, financing for hydropower development promotion is one of the key objectives in the Policy. The developer is obligated to pay an up-front premium to the government as a down payment before commencement of construction. In addition to this, after starting operation, for 12 years, it has to pay the government as a royalty the equivalent of a minimum of 12% of power generation output, and for the remaining period, the equivalent of a minimum of 18% of power generation output. Some of these funds are pooled into the Renewable Energy Development Fund (REDF) managed by the government, and utilized for hydropower development-related costs, environmental costs, compensation of electricity prices, development of other renewable energy etc.

Furthermore, foreign direct investment (FDI) is also covered by the Policy. For large hydro (more than 150MW), 100% of foreign capital or a Joint venture (JV) with a Bhutan national company is possible. It is also noted that the FDI investors, for the first 10 years, can enjoy preferential treatment, including corporation income tax exemption.

Power sector not only contributes to economic growth in Bhutan but also to its foreign exchange earnings. The World Bank estimates in its "Bhutan: Country Snapshots (March 2014)" that power exports account for 25 percent of Bhutan's gross domestic product (GDP) and hydropower infrastructure development maintains effects to raise another 25 percent of GDP through construction sector. Trade statistics published by the Ministry of Finance show that power export accounts for 38.7 percent of all exports from Bhutan to India in 2013.

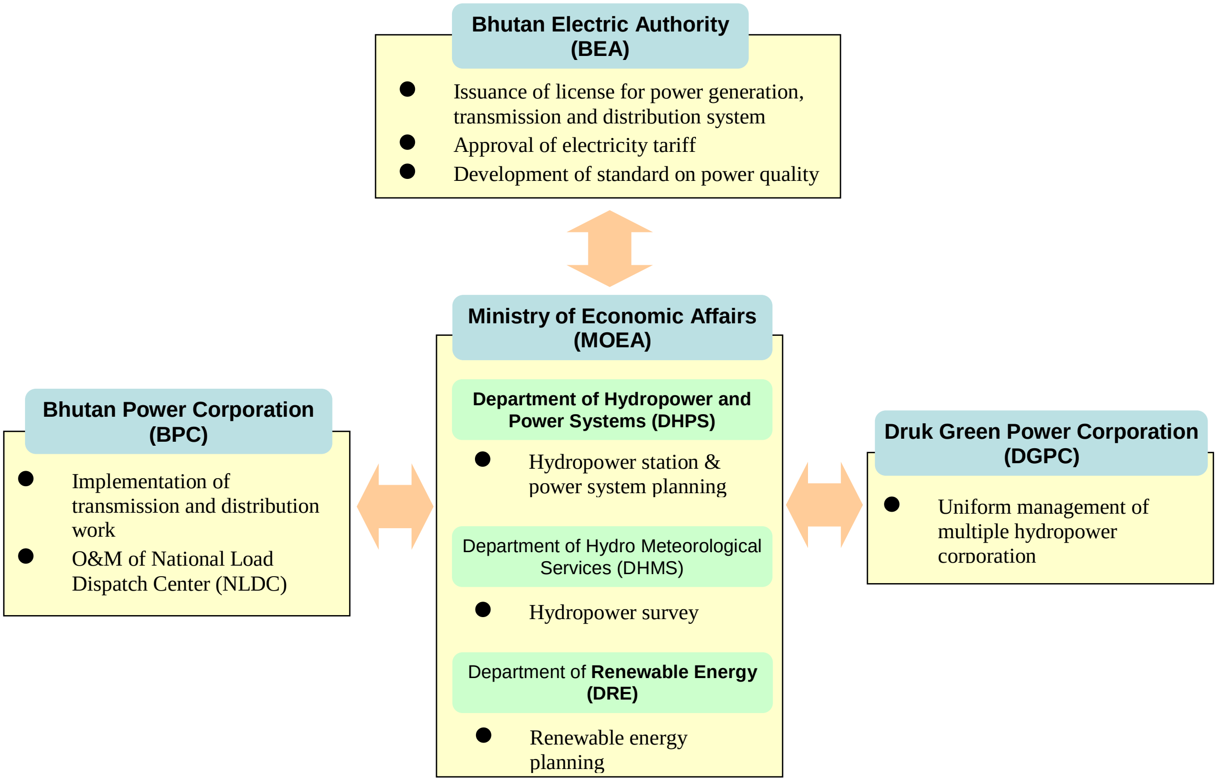
2.2.2 Organizational Structure of Power Sector

The Electricity Act of Bhutan was amended in July 2001 to effectively and efficiently implement the promotion of rural electrification and hydropower development. The Electricity Act enables the restructuring of the power sector, splitting the Department of Power, under the Ministry of Trade and Industry (MTI), into three newly established organizations: the Department of Energy (DOE), the Bhutan Energy Authority (BEA), and Bhutan Power Corporation (BPC). Major hydropower stations were also publicly incorporated in July 2002.

DOE performs various functions, such as formulating energy policy and power development plans, and administrating the power and mining sectors.

As part of an administrative reform on 17th October 2007, DOE became a subsidiary of the Ministry of Economic Affairs (MOEA).

BEA is the regulatory authority in charge of developing licensing for generation and tariff-setting.
In December 2011, MTI became the MOEA, and DOE, under the MOEA, split into three Departments: the Department of Hydropower & Power System (DHPS), the Department of Hydro-Met Services (DHMS), and the Department of Renewable Energy (DRE).
The organization chart for the power sector is shown in Figure 2-8.



(Source: JICA Survey Team)

Figure 2-8 Organizational Structure of Power Sector

(1) Planning
DHPS in MOEA executes the planning of hydroelectric power plants and large-scale transmission lines.

(2) Construction and O&M of hydropower plants
The government of Bhutan and the government of India jointly compose a "Hydroelectric Project Authority" for each project, and that organization executes the construction of a large-scale hydroelectric power plant. DGPC carries out operation and maintenance (O&M) uniformly after construction ends.

(3) Construction and O&M of transmission lines
Bhutan Power Corporation (BPC) executes construction of all transmission lines in Bhutan territory to transport the electric power from the hydropower plants. BPC owns the transmission lines and carries out O&M after construction ends.

2.2.3 Status of Demand-Supply Balance

(1) Imbalance between supply and demand

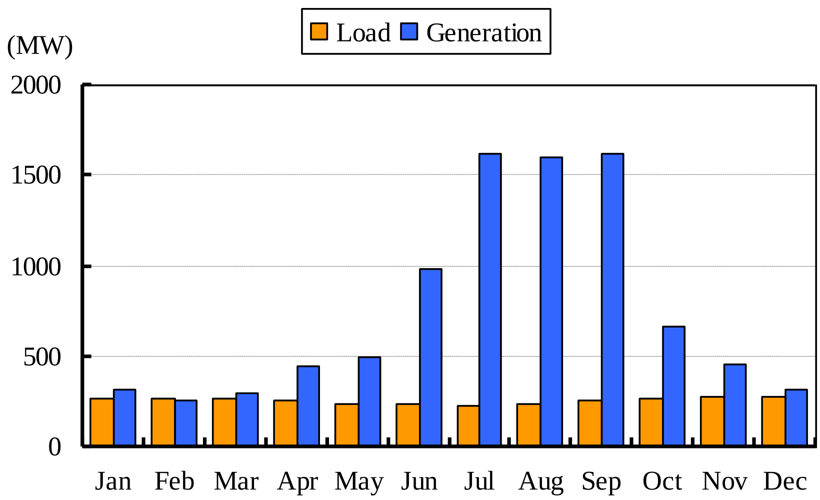
The Chhukha hydropower station, with an installed capacity of 336 MW, was commissioned in 1986 as the first large-sized hydropower station in the country and after that, similar stations financed by India were developed for the purpose of power exports to India. As a result of the commissioning of Tala hydropower station in 2006, with an installed capacity of 1,020 MW, the total installed capacity of hydropower, including small hydropower, amounted to 1,488 MW as of June 2013. This has easily exceeded the domestic peak power demand of approximately 280MW. During FY 2012 power exports were 4,896 GWh, accounting for 71% of the total electricity generation (6,883 GWh).

The peak power demand records the maximum in winter, which was approximately 280 MW in November 2012. There exists approximately 1,500 MW of hydropower generation, and it seems that there is sufficient supply capacity. However, since all hydropower stations are run-of-the-river types, electricity generation varies widely by season. Therefore, the amount of water will decline significantly in the dry season, and will only provide a supply capacity of approximately 300 MW. As a result, there are some regions where supply capacity will be insufficient, and only a small amount of electric power may be imported from Assam State and West Bengal State of India. The total amount of power imports from India was 56 GWh in FY 2012. The difference between supply capacity and peak demand on a month-by-month basis is shown in Figure 2-9.

Table 2-9 Generation Facilities (FY 2012)

	Installed capacity (MW)	Electricity generation (GWh)
Chhukha hydropower	336	1,745.3
Kurichhu hydropower	60	360.9
Basochhu-I hydropower	24	299.8
Basochhu-II hydropower	40	
Tala hydropower	1,020	4,405.2
Other hydropower	8	15.2
All diesel generators	9	0.2
Total	1,497	6,826.7

(Source: Power data book 2012 (BPC))

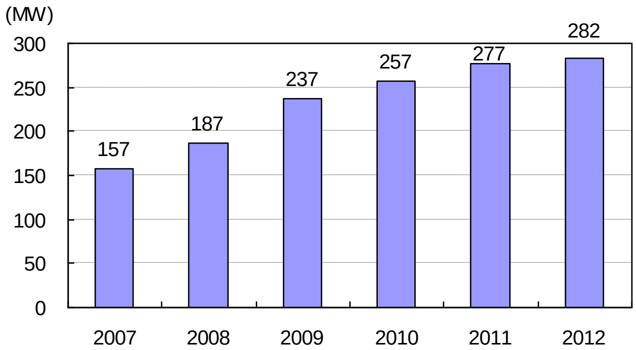


(Source: Power data book 2012 (BPC))

Figure 2-9 Monthly Difference between Supply and Peak Demand in FY 2012

(2) Peak power demand

Peak power demand is increasing year by year and recorded 282 MW in FY 2012, with a steady increase of 2.2% from the previous year amounting to 1.8 times that of FY 2007.



(Source: Power data book 2012 (BPC))

Figure 2-10 Changes in Peak Power Demand

(3) Demand forecast

Demand forecast until 2020 is formulated by BPC as shown in Table 2-10. The main assumptions are as follows.

- Trend analysis was adopted for the industrial and residential load for eastern and western regions.
- Forecasting for construction power was included based on the hydropower development plan.
- Annual average growths observed for industrial and residential sectors from 2012-2020 were 9% and 7% respectively in line with the anticipated GDP growths of 6-7% on average for the same duration.

Table 2-10 Demand Forecast until 2020 by BPC (MW)

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential + Commercial	96	104	111	119	126	134	142	149	157
Industrial	219	242	265	289	312	335	358	382	405
Construction power	13	21	45	67	88	115	95	62	30
Demand Total	328	367	421	474	526	584	596	593	591

(Source: BPC Engineering/designing & Contracts Dept.)

According to the "National Transmission Grid Master Plan (NTGMP) for Bhutan", formulated jointly by DHPS and CEA in India in 2012, the power demand forecasts in Bhutan for 2020 and 2030 are estimated to be approximately 1,500 MW and 2,500 MW, respectively. The reason for the very much higher load forecast is that the attraction of factories, such as an aluminum production factory in southern Bhutan, is taken into consideration.

(4) Power development plan

The commencement of commercial operation of Punatsangchhu-II and Mangdechhu are scheduled in 2018, and that of Punatsangchhu-I is scheduled in 2019. In consideration of these, the installed capacity until 2020 is shown below. It has enough reserve capacity for the above-mentioned forecasted demand.

Table 2-11 Installed Capacity until 2020

(MW)

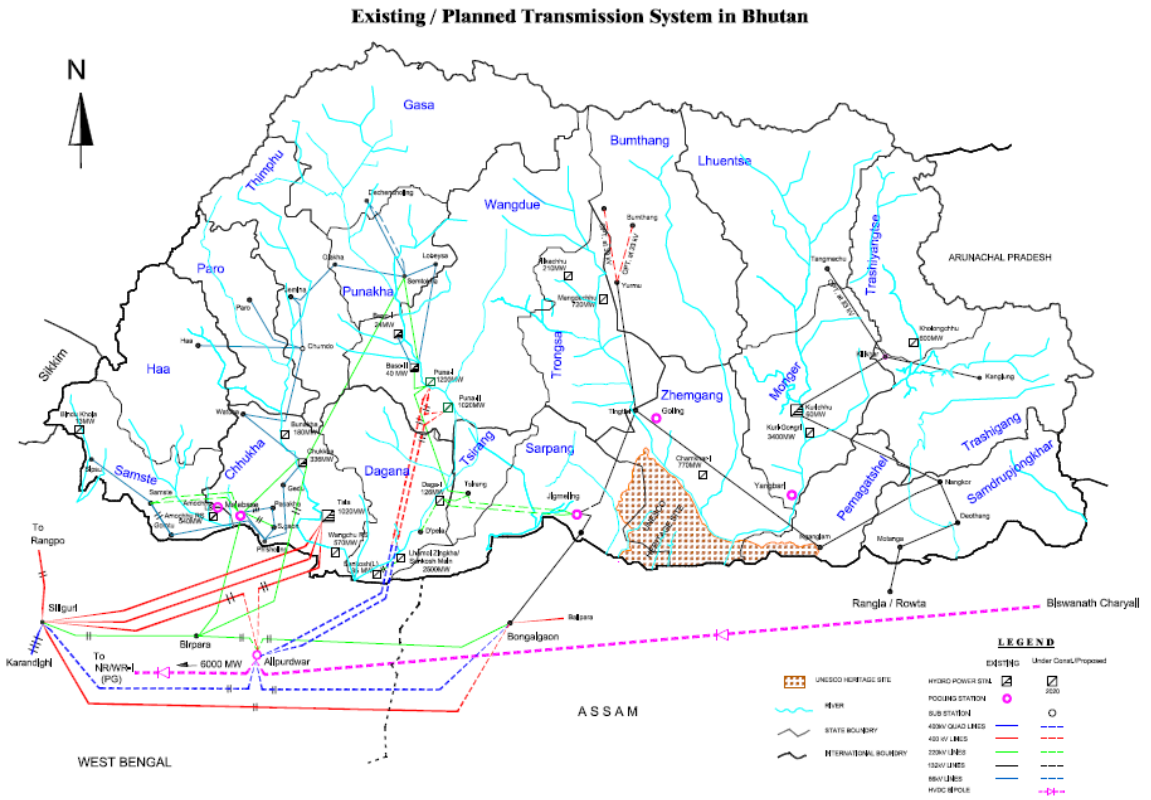
	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497	1,497
Dagachhu				126	126	126	126	126	126
Punatsangchhu-I								1,200	1,200
Punatsangchhu-II							1,020	1,020	1,020
Mangdechhu							720	720	720
Total (Installed capacity)	1,497	1,497	1,497	1,623	1,623	1,623	3,363	4,563	4,563

(Source: JICA Survey Team)

2.2.4 Bhutan Power Grid

(1) Domestic power grid in Bhutan

A 400kV transmission line interconnected to India is under construction according to the hydropower development of 1,000MW class in western Bhutan. Moreover, the direct current power transmission line in India which it is connected to is under construction, and construction will be completed next year.



(Source: National Transmission Grid Master Plan for Bhutan (CEA) April 2012)

Figure 2-11 Power Grid Map of Bhutan

Table 2-12 Existing Export Interconnections from HEPs

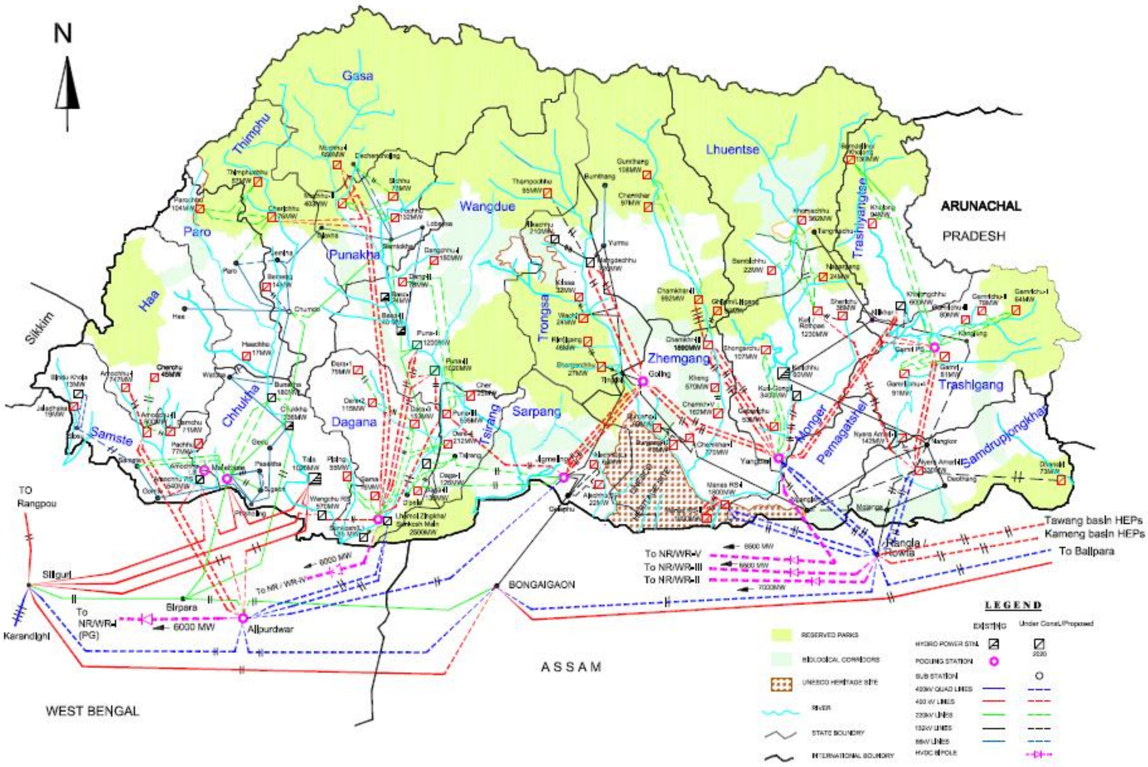
Existing export Interconnections from HEPs			
Voltage Level (kV)	Transmission Link	No. of Ckt.	Export Power Plant
400	Tala - Khogla - Binnaguri / New Silliguri	Double	Tala
	Tala - Pagli / Malbase - Binnaguri / New Silliguri	Double	Tala
220	Chukha - Pling - Birpara	Double	Chukha
	Chukha - Malbase - Birpara	Single	Chukha
132	Kurichhu - Gelephu - Salakati	Single	Kurichhu
	Kurichhu - Deothang / Motanga - Rangia	Single	Kurichhu

(Source: SARI/EI workshop (Bhutanese team, March 2014))

Ref: ±800kV HVDC Multi Terminal System (Agra (NR) – Alipurduar – Biswanath Chariali) will be Completed 2014/15

(2) Cross-border transmission lines to India

The Power System expansion plan at 2030 is shown below. This plan is described in "National Transmission Grid Master Plan (NTGMP) for Bhutan", formulated jointly by DHPS and CEA in India in 2012. The basic concept of the master plan is to export the electric power generated from abundant hydropower resources in Bhutan to India.



(Source: SARI/EI workshop (Bhutanese team, March 2014))

Figure 2-12 Power System expansion plan at 2030 (April 2014, CEA)

Table 2-13 Under Construction Export Interconnections from HEPs

Under Construction export Interconnections from HEPs				
Voltage Level (kV)	Transmission Link	No. of Ckt.	Conductor	Lenth in Route (km)
400	Punatsangchhu I HEP-Lhamoizingkha	Double	Twin Moose	93
	Lhamoizingkha-Alipurduar	Double	Quad Moose	45
	Mangdechhu HEP-Jigmeling	Double	Twin Moose	80
	Jigmeling- Alipurduar	Double	Quad Moose	130
	Punatsangchhu II HEP-Jigmeling	Double	Quad Moose	65
Total				413

(Source: SARI/EI workshop (Bhutanese team, March 2014))

2.3 India

2.3.1 Power System Development Policy in India

In India, national energy consumption has continued to grow due to recent annual economic growth of approximately 6%, and its primary energy consumption (toe: tonne of oil equivalent) was the 4th largest country in the world in 2014. The Electricity Act (2003) was enacted to facilitate power sector development in India, which covers generation, transmission, distribution, electricity market and etc. The power sector business has been operated based on this act.

As per the requirements of the act, the Central Electricity Authority (CEA) is to prepare and update the National Electricity Plan once every five years in accordance with the National Electricity Policy developed in 2005. The plan is published after stakeholder & public consultation and approval by the Central Government.

The National Electricity Plan covers a short-term energy plan for 5 years and a perspective for the coming 15 years. It includes the following topics:

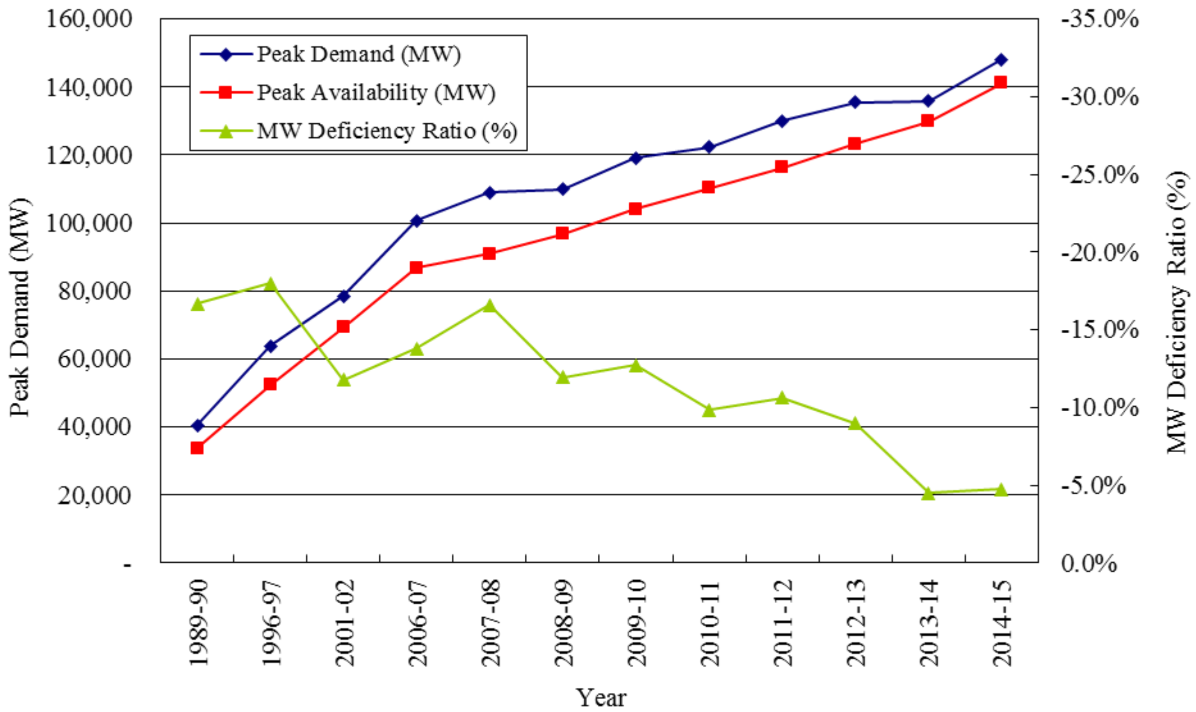
- Demand forecast
- Areas and/or locations which require power system development
- Different technology application for economic development
- Fuel mix

Figure 2-13 and Figure 2-14 show peak demands and electricity demand for each year. As can be observed in the figures, the power demand has been increasing rapidly in India. India has been facing supply shortages of electricity for more than two decades, and the deficit was either stable or increased during the period of the 11th Five Year Plan of 2007-2012. The power deficiency rates for the last two years have been decreasing to around 5%, reflecting the sluggish economy. Though it has improved, India has still been experiencing a power deficiency and further power development is necessary.

CEA issued the National Electricity Plan (Volume I) – Generation of 12th Five Year Plan in January 2012. An outline of the power development strategy is also included in "Twelfth Five Year Plan (2012-2017) Volume I", issued by the Planning Commission of GOI.

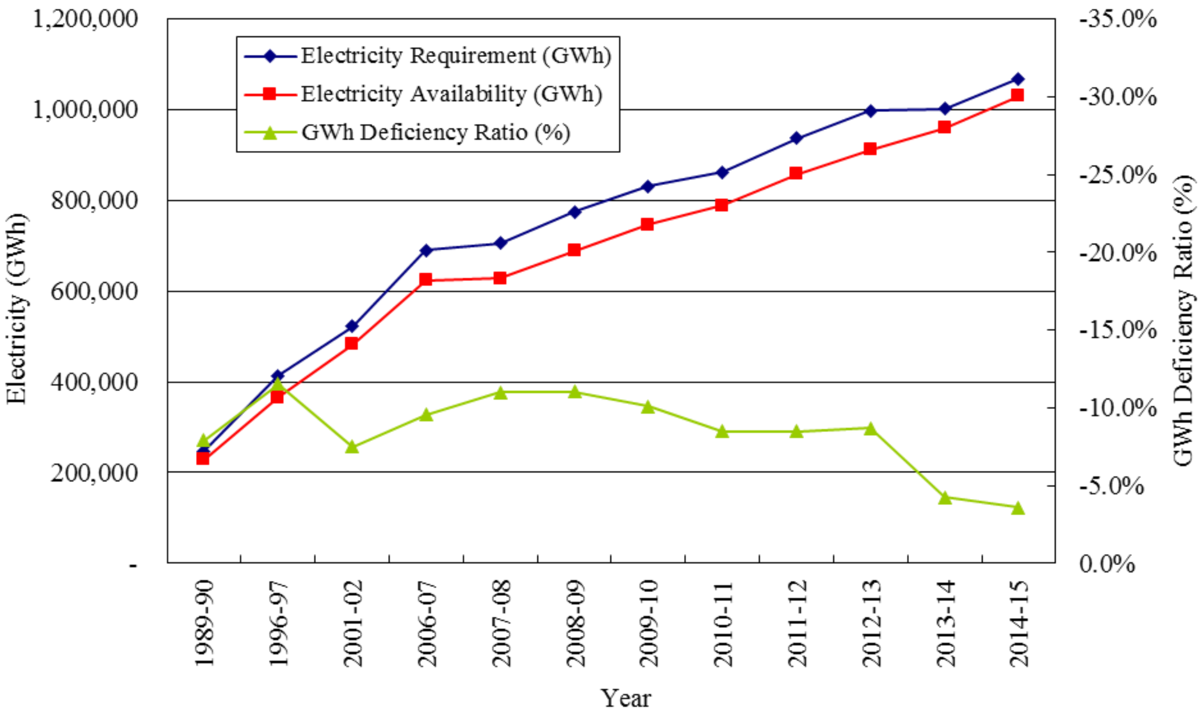
In the plan, it is recommended to assume a power demand forecast based on the 18th Electric Power Survey (EPS) by the CEA, shown in Table 2-14 and Figure 2-15, for generation planning for the 12th (2012-2017) and 13th Five Year Plan (2017-2022). It estimates that the energy consumption in India will expand at a yearly rate of approximately 7% in the coming decade. However, the actual energy consumption growth was less than its estimation for recent years. According to the Load Generation Balance Report 2015-16 (LGBR 2015-16) by CEA, the demand forecast for 2015-16 of 1,162,423 GWh is 7.5% lower than the forecast in the 12th Five Year Plan (1,256,413 GWh) in consideration of the latest low demand growth.

In order to meet the demand increase, it plans to add new conventional power generation of 79,690 MW and renewables of 18,500 MW during the 12th plan period, and conventional power of 79,200 MW and renewables of 30,500 MW during the 13th plan period. Coal will continue to be a dominant source of power in future in India, and a Low Carbon Growth Strategy is introduced to reduce CO2 gas emissions for sustainable power development. In particular, wind and solar energies are potentially promising renewable power sources in India. In June 2015, the Union Council of Ministers, chaired by the Prime Minister, approved the ramping up of India's solar power capacity to 100,000 MW by 2022, consisting of 40 GW of rooftop and 60 GW of large- and/or medium-size solar projects, from its original plan of 20,000 MW by 2022.



(Source: National Electricity Plan Volume I Generation, January 2012, CEA & Load Generation Balance Reports, CEA)

Figure 2-13 Electricity Demand of India (GW)



(Source: National Electricity Plan Volume I Generation, January 2012, CEA & Load Generation Balance Reports, CEA)

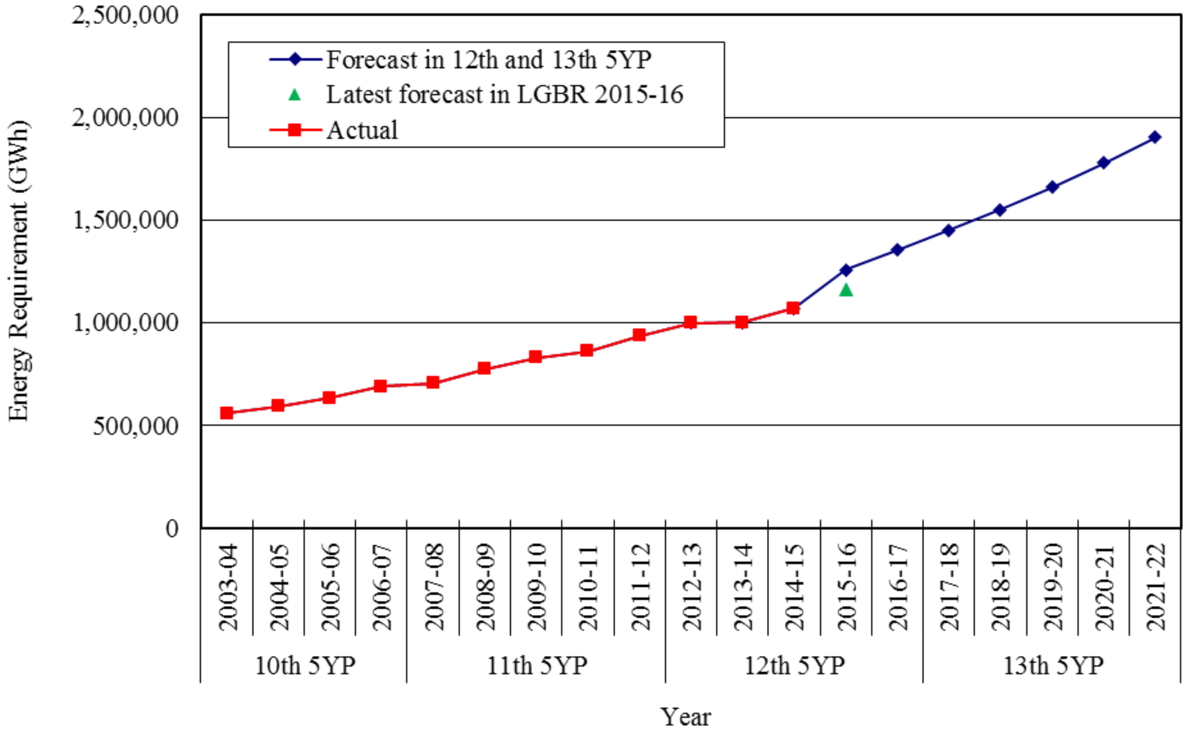
Figure 2-14 Electricity Demand of India (GWh)

Table 2-14 Demand Forecast of Each State in the 18th Electricity Power Survey

[MW]

State/Uts	2011-12	2016-17	2021-22	2026-27	2031-32
Delhi	4,770	6,398	9,024	12,681	17,246
Haryana	6,376	10,273	14,244	20,103	27,202
Himachal Pradesh	1,335	1,900	2,589	3,424	4,476
Jammu & Kashmir	1,802	2,687	4,217	5,996	8,302
Punjab	8,363	12,342	14,552	18,352	23,144
Rajasthan	8,097	13,886	19,692	28,828	40,284
Uttar Pradesh	12,021	23,081	36,061	53,690	73,708
Uttarakhand	1,656	2,189	2,901	3,911	5,222
Chandigarh	336	426	559	732	948
Northern Region	**37,265**	**60,934**	**86,461**	**121,979**	**164,236**
Goa	530	815	1,192	1,658	2,216
Gujarat	11,556	19,091	26,973	38,691	53,301
Chhattisgarh	3,155	4,687	6,599	9,090	12,116
Madhya Pradesh	8,897	13,904	18,802	27,519	38,088
Maharashtra	18,398	28,645	39,622	54,982	74,528
D. & N. Haveli	640	944	1,297	1,733	2,294
Daman & Diu	308	441	605	818	1,082
Western Region	**39,351**	**62,015**	**86,054**	**120,620**	**163,222**
Andhra Pradesh	14,122	22,445	33,194	51,601	74,818
Karnataka	8,545	13,010	18,403	25,396	34,720
Kerala	3,489	4,669	6,093	8,150	10,903
Tamil Nadu	12,271	20,816	29,975	43,044	59,127
Pudducherry	497	630	782	787	940
Southern Region	**36,175**	**57,221**	**82,199**	**118,764**	**165,336**
Bihar	2,226	5,018	9,306	16,239	23,411
Jharkhand	3,201	4,616	6,341	8,780	11,930
Odisha	3,964	5,672	6,749	8,712	11,280
West Bengal	7,454	11,793	17,703	26,027	36,187
Sikkim	106	144	176	245	341
Eastern Region	**15,122**	**24,303**	**35,928**	**53,053**	**72,874**
Assam	1,257	1,817	2,534	3,613	5,033
Manipur	171	346	497	869	1,212
Meghalaya	361	445	596	828	1,112
Nagaland	130	185	271	403	554
Tripura	239	340	472	674	913
Arunachal	88	135	177	266	365
Mizoram	160	285	352	521	723
North Eastern	**2,021**	**2,966**	**4,056**	**6,169**	**8,450**
Andaman	51	67	89	125	172
Lakshadweep	7	11	18	23	30
India	**124,995**	**199,540**	**283,470**	**400,705**	**541,823**

(Source: 18th Electricity Power Survey by CEA)



(Source: National Electricity Plan Volume I Generation, January 2012, CEA & Load Generation Balance Reports, CEA)

Figure 2-15 Demand Forecast in 12th 5 Year Plan

Table 2-15 shows the energy balance of India. India has a large amount of coal reserves, and 45% of its total energy consumption was supplied by coal in 2012. Regardless of its large amount of coal reserves, India has been facing a deficiency of primary energy supply, and has been increasing imports of the primary energy supply to satisfy the increasing energy demands. India is a net importer of crude oil and gas. According to IEA statistics, the self-sufficiency ratio of primary energy for India was 69% in 2012, and it has slowly declined over the last twenty years.

Table 2-15 Energy Balance of India in 2012

(Thousand tons of oil equivalent)

Items	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geothermal Solar	Biofuels & Waste	Electricity	Total
Production	260,524	43,334		33,338	8,566	10,821	3,079	184,892		544,554
Imports	90,629	188,860	15,988	15,590					412	311,480
Exports	-2,114		-66,144							-68,258
International marine bunkers			-1,224							-1,224
International aviation bunkers			-3,930							-3,930
Stock changes	5,208	831	-535							5,504
Total primary energy resource	354,247	233,025	-55,845	48,928	8,566	10,821	3,079	184,892	412	788,126
Total final consumption	88,329		148,419	26,190			466	173,422	74,713	511,539
Industry	77,135		18,856	9,072			28	29,941	32,979	168,010
Transport			70,342	1,649				209	1,327	73,527
Residential	3,041		23,016	2,486			373	136,689	16,415	182,020
Common and Public services	4,109		1,358				42	6,582	6,539	18,630
Agriculture/forestry			9,657	155					13,168	22,980
Non-specified	4,045		2,386				23		4,285	10,739
Non-energy use			22,805	12,828						35,633

(Source: Energy Balance of Non-OECD Countries 2014 Edition by IEA)

2.3.2 Power Sector of India

Both the central government and state governments of India are responsible for development of the power system, policy formulation, and regulation and monitoring of power projects in India, and the power business is operated by the central & state power units, who are subsidiaries of the central and/or state governments, and private power developers. There are several ministries and organizations in the central government of India related to the power sector as shown in Figure 2-16. State utilities such as state-owned generating, transmission and transmission companies are responsible for the planning, construction, operation and maintenance of intra-state facilities.

(1) Ministry of Power (MOP)

The Ministry of Power plays a key role in the power sector. It is responsible for power system planning, policy formulation, processing of projects for investment decision, monitoring of the implementation of power projects, training and manpower development and the administration and enactment of legislation in regard to thermal and hydro power generation, transmission and distribution. It doesn't cover nuclear power and renewable energy fields.

(2) Central Electricity Authority (CEA)

As per the Electricity Act 2003, the Central Electricity Authority is a technical organization to assist and support the central government of India regarding power sector development in India. Power system planning and development are conducted by CEA. CEA is also responsible for the following items:

- Technical standards for power generation, transmission and distribution
- Safety rules for construction, operation and maintenance for power generation, transmission and distribution
- Installation rules and conditions for meter installation at transmission lines and generations

CEA is also responsible for overall hydro power development in India in consideration of optimum water resource utilization including drinking water, irrigation, navigation, flood-control, and other public purposes. Tasks and Duties of CEA include assessment of hydro power potential, providing assistance to states on investigation, preparation of project reports, construction & investigation monitoring of hydro power projects etc. It is mandatory to get approval from CEA to construct new hydro power stations in India.

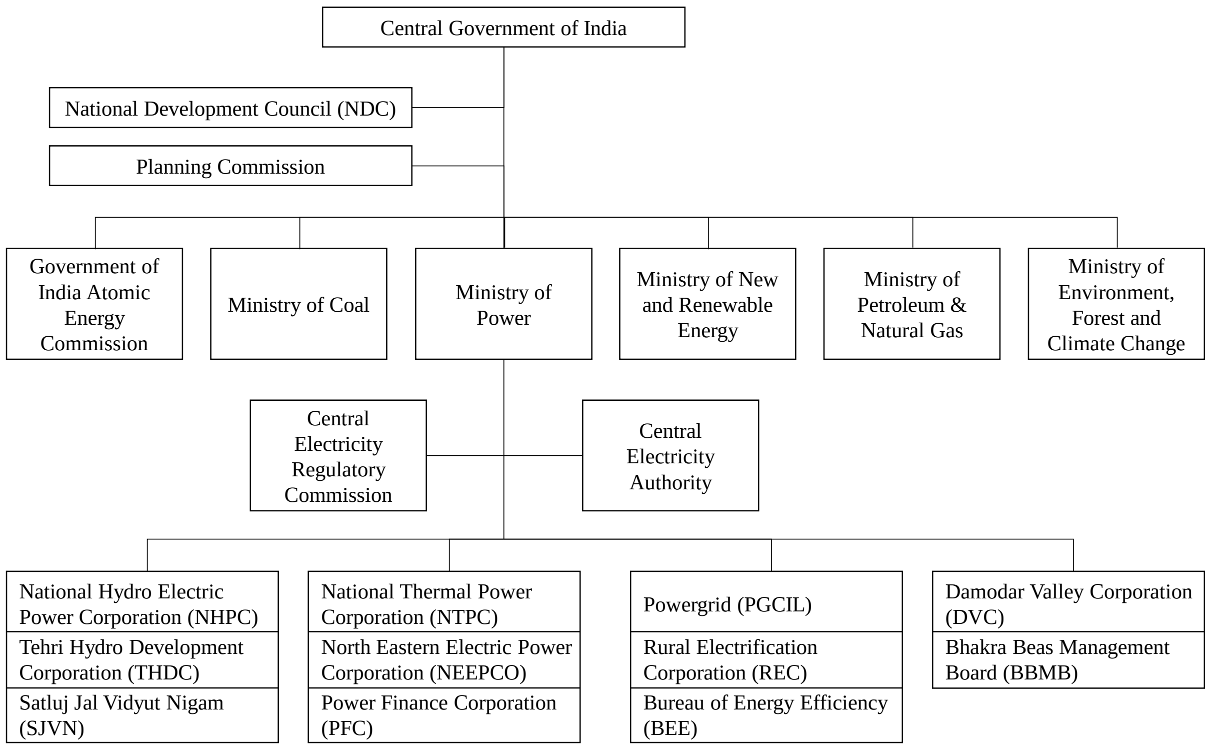
(3) Central Electricity Regulatory Commission (CERC)

The Central Electricity Regulatory Commission is the central regulator of the power sector in India and also an advisor to the central government. The major missions of CERC are to formulate electricity tariffs, to promote competition, and to facilitate improvements in the efficiency of the power supply and its quality. The following is a list of tasks for which CERC is responsible:

- Regulation of generation tariff of generating companies owned or controlled by the central government
- Regulation of generation tariff of generating companies other than those owned or controlled by the central government and the generation and sale of electricity in more than one state
- Regulation of inter-state power transmission
- Determination of tariff for inter-state transmission lines
- Issuance of licenses to transmission system developers and power traders who are doing inter-state business

(4) Power Grid Corporation of India Limited (PGCIL)

The Power Grid Corporation of India Limited is the central transmission unit. It is responsible for the planning, construction, operation and maintenance of inter-state transmission lines in India. Intra-state transmission lines are planned, constructed, operated and maintained by state transmission utilities.



(Source: JICA Survey Team)

Figure 2-16 Organizations related to Power Sector of India

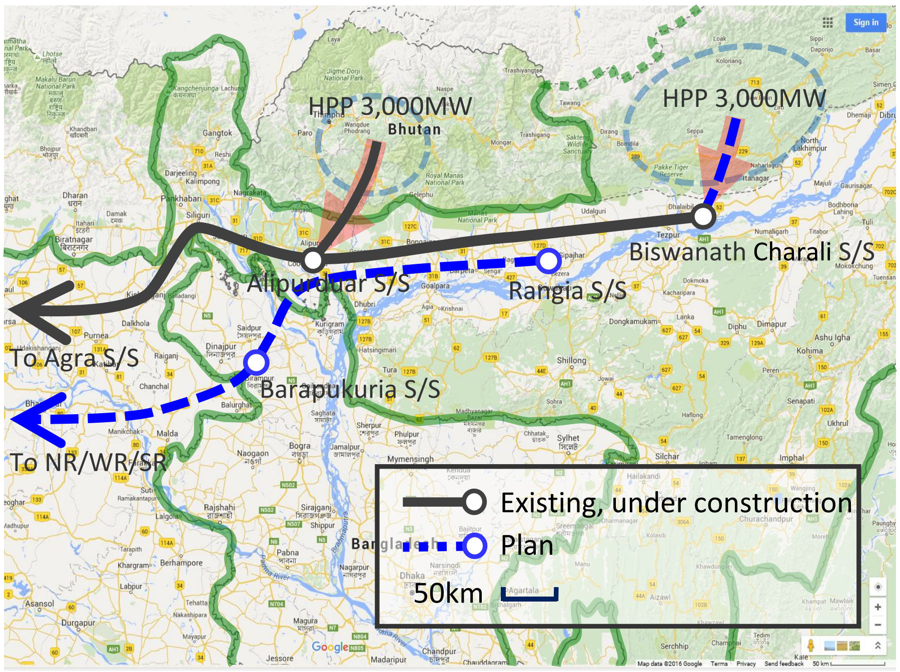
2.3.3 Power Demand of Eastern and North Eastern Regions of India

Figure 2-18 shows the power system of eastern India, which is controlled by Eastern Region Load Dispatching Center, owned by PGCIL. The power systems of western Bangladesh and eastern India have been connected via the first HVDC (Back-to-Back) interconnector in the South Asia region, which has a 500MW capacity, since February 2014, via support from the Asian Development Bank. Currently, India is pushing power to Bangladesh to support their demand. The 400kV Berhampur substation in India is connected to the 230kV Bheramara substation in Bangladesh.

Figure 2-20 illustrates evening peak demands (18:00 or 19:00 hrs.) of the eastern region of India on the first day and third Wednesday of each month in 2014. It can be observed that the evening peak demand is almost constant at around 15,000MW throughout the year. Figure 2-21 illustrates supply shortages at the evening peak on the same dates. According to this figure, Bihar state, whose peak demand is around 2,000MW in 2014, faced a large amount of supply shortages from July to December in 2014. On the other hand, West Bengal, which has the largest demand in the region, didn't experience a large deficiency of supply throughout the year. As shown in Table 2-14, the regional demand is expected to be more than double in the coming ten years. West Bengal state has the largest demand in this region, and the rapid growth of this state is also expected.

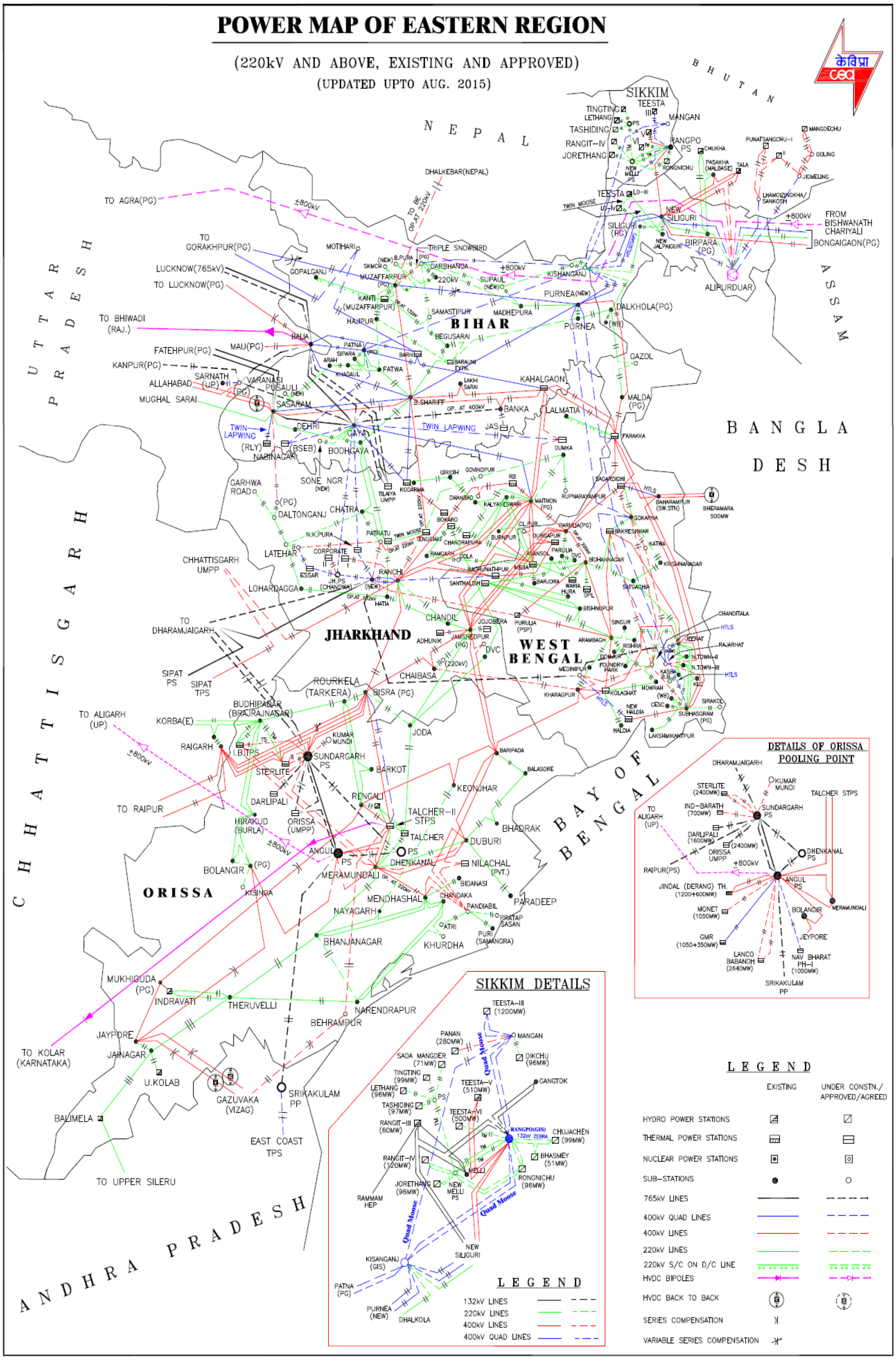
The hydro power plants of L Subansiri (2,000MW) and Kameng (600MW) in Arunachal Pradesh state in India, and Punatsangchhu I & II (2,220MW) and Mangdechhu (720MW) in the western region of Bhutan are under construction. The ±800kV DC transmission line shown is under construction in order to transmit the power generated in those power plants toward Delhi.

DC Voltage	±800kV
Length of overhead DC line	1,728km
Transmission capacity	6,000MW
No. of poles	Converter: 4, Line : 2
Start of project year	March 2011
Commissioning year	2014-2015



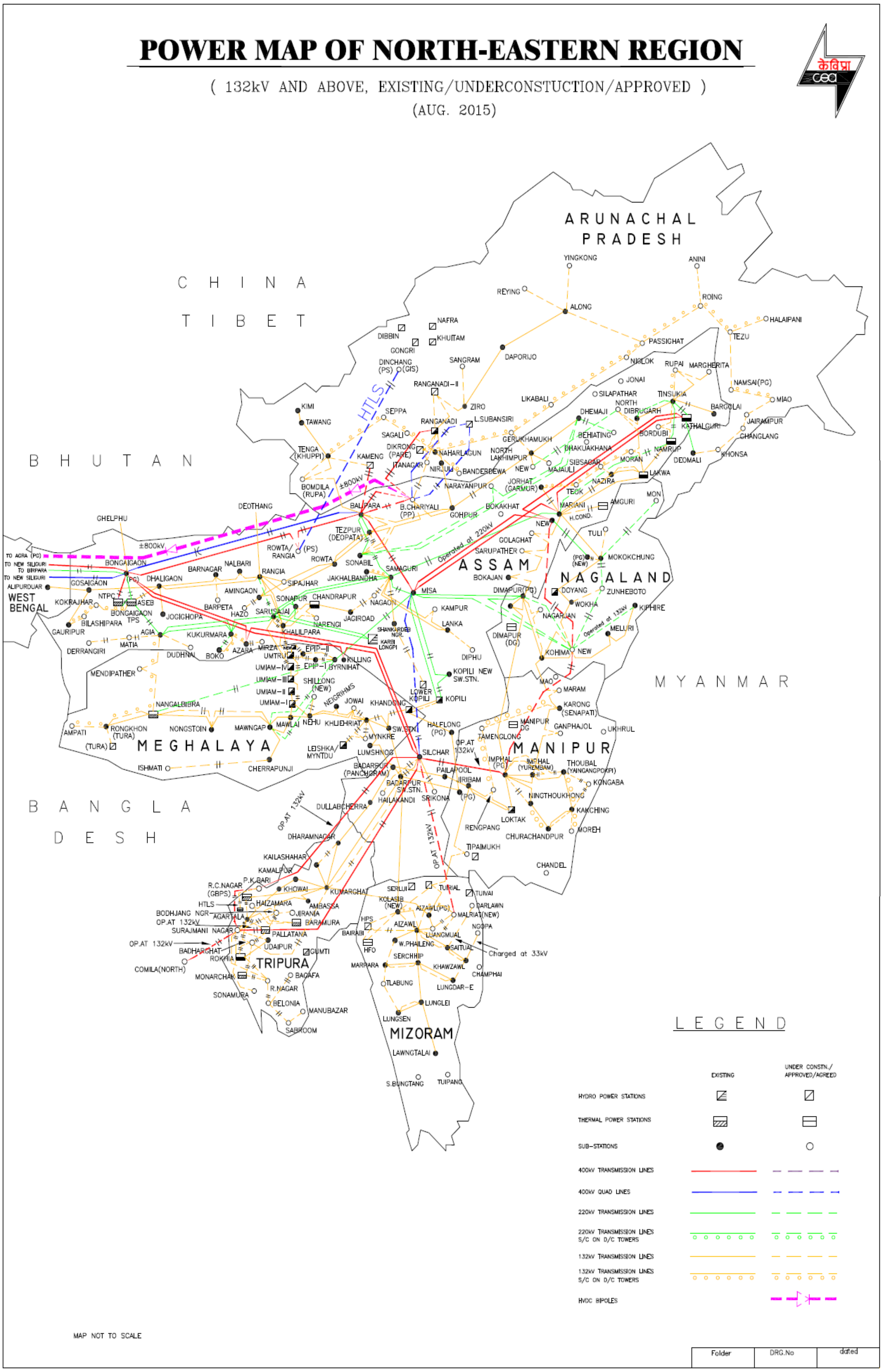
(Source: JICA Survey Team)

Figure 2-17 ±800kV DC Transmission Line Under Construction in India



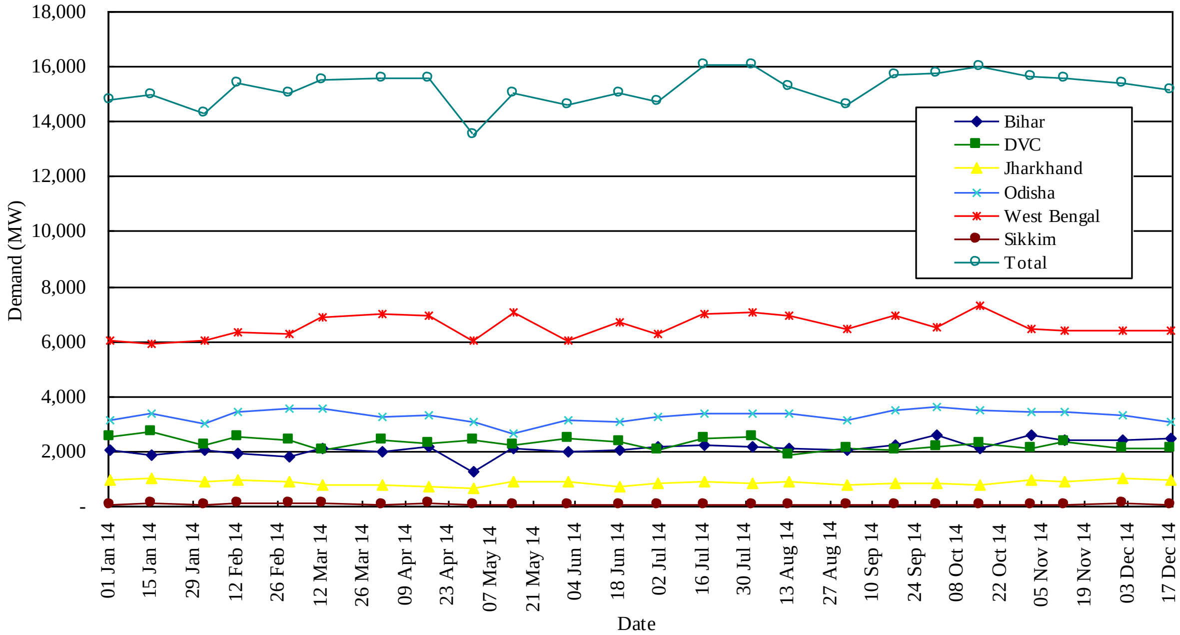
(Source: CEA)

Figure 2-18 Power System in Eastern Region of India



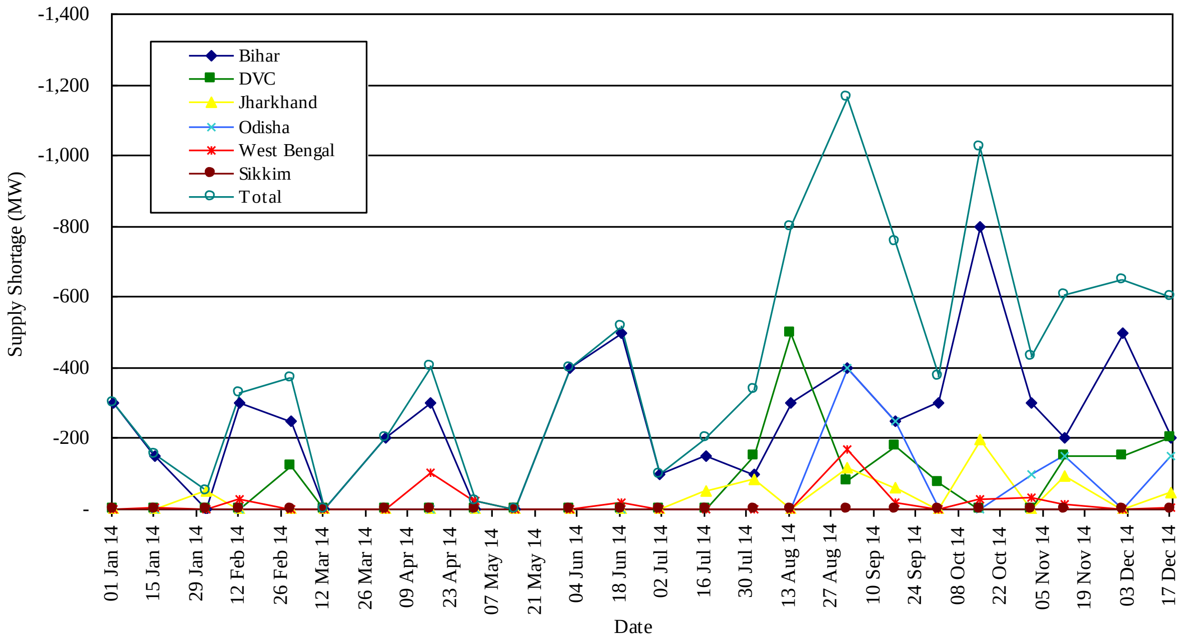
(Source: CEA)

Figure 2-19　Power System in North-Eastern Region of India



(Source: Eastern Region Load Dispatching Center of India)

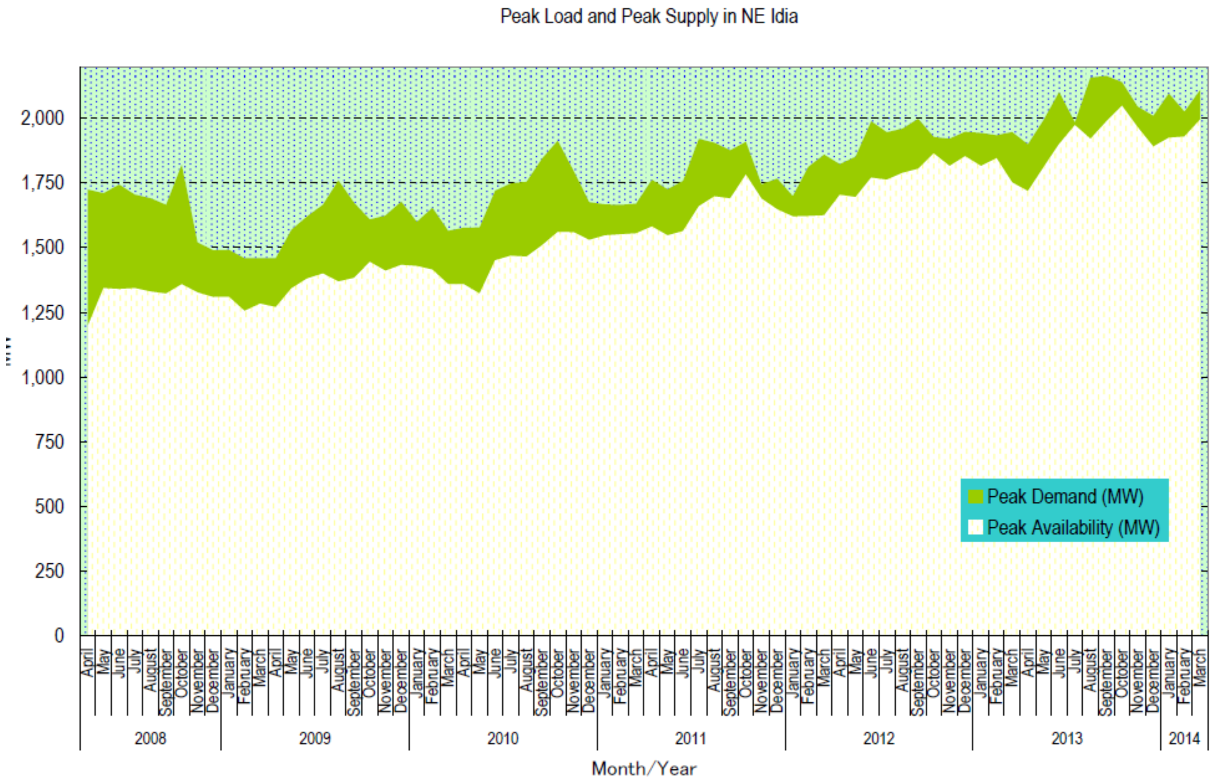
Figure 2-20 Evening Peak Demand of Eastern Region of India (18:00 or 19:00hrs, Not Day Peak)



(Source: Eastern Region Load Dispatching Center of India)

Figure 2-21 Supply Shortage of Eastern Region of India (18:00 or 19:00hrs, Not Day Peak)

Figure 2-22 illustrates monthly peak demand and supply from April 2008 to March 2014 in the North Eastern States of India. There used to be a chronic supply capacity deficit until 2010 in NE India. However, as thermal capacity increased, the regional supply availability gradually caught up with the increasing demand over the years. It is expected that the upcoming hydropower uptake will give the NE region a huge surplus of peak availability that can be traded with other regions in India or neighboring countries.



(Source: Load Generation Balance Reports – CEA, India, processed by JICA Survey Team)

Figure 2-22 Peak Supply and Demand Balance in North Eastern Region of India

2.4 Nepal

2.4.1 Energy Policy

(1) Thirteenth Three-Year Plan (FY2013/14-2015/16)

The National Planning Commission of Nepal published the 13th Three-Year Plan (FY2013/14 – 2015/16) in July 2014. Development of the hydropower and energy sectors, productivity growth of the agro sector and its diversification and commercialization, basic education, health, drinking water and sanitation, good governance, expansion of roadways, development of physical infrastructures, tourism and trade are the priorities.

(2) Power Sector Development Policy

The Government of Nepal has set the following key targets to be met by the year 2027: (i) increasing per capita electricity consumption to 400 kWh per year (106 kWh during 2011); (ii) commissioning 4,000 MW of generation capacity (787MW at the end of FY2013/14); (iii) providing electricity to all of the population through either the national grid or off-grid solutions (electrification rate of 76.3% in 2010); and (iv) developing considerable exportable hydropower capacity.

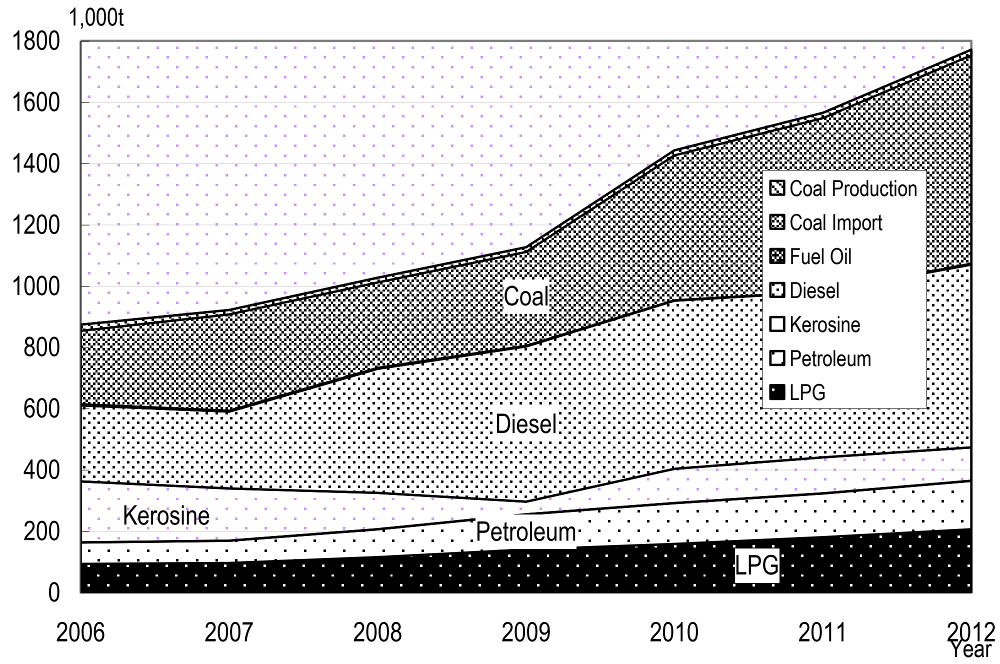
(3) Hydropower Development Policy

The Government of Nepal has maintained its Hydropower Development Policy over 20 years. The latest policy was published in 2001. According to it, there are three main objectives, i) to develop small and decentralized hydropower projects to meet the local demands in remote and isolated regions of the country, ii) to develop medium sized power projects to meet the national demand within the national grid, including surplus for export, and to develop local capacity, and iii) to develop large-scale multi-purpose projects in order to meet the regional demand for food, energy and flood control.

(4) Domestic Energy Resources in Nepal

Whereas there is very limited volume of fossil fuel deposits in the country, Nepal is endowed with huge hydropower potential. The total theoretical hydropower potential is estimated at 83,000 MW, out of which 43,000 MW is considered to be economically viable. Numerous prospective hydropower potential areas exist in the major basins of Koshi, Gandaki, and Karnali. However, due to the lack of a viable framework for hydropower development, such great potential has not been effectively harnessed.

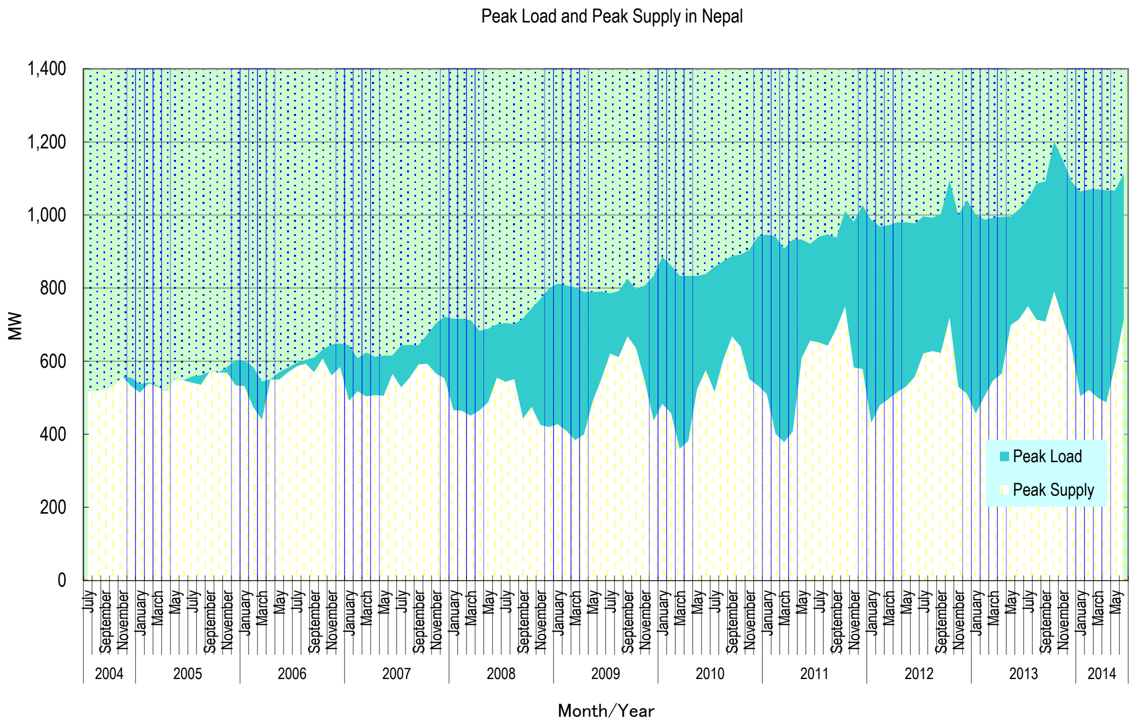
Nepal is a net energy importer. Most of the fuel is imported from the rest of the world. The volume of fuel imports has doubled between 2006 and 2012 as the following figure indicates. As economic activities increase in the post conflict period, coal and diesel imports increase mainly for commercial and industrial purposes.



(Source: IEA Energy Balance)

Figure 2-23 Fossil Energy Imports in Nepal

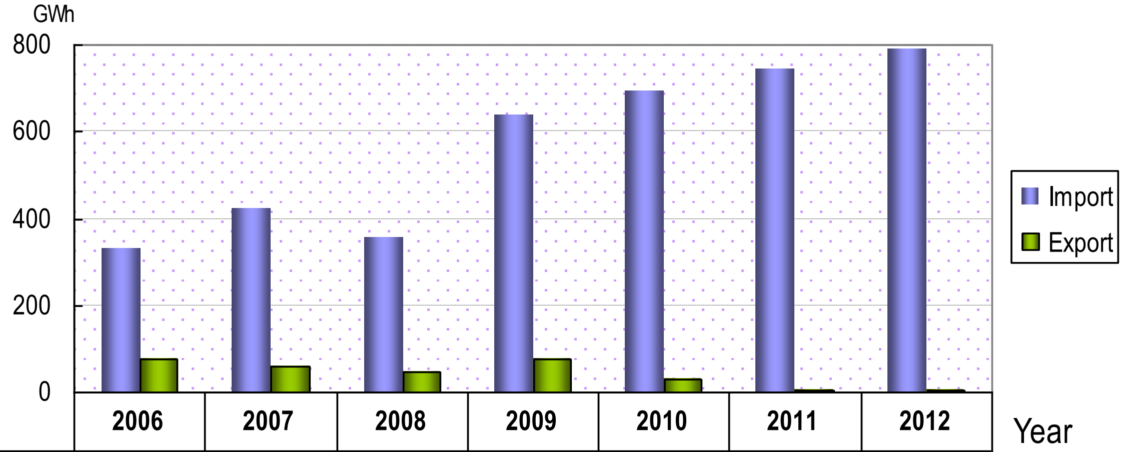
Looking at the power supply demand balance in Nepal, Figure 2-24 depicts that there has been almost no additional generation capacity over 10 years, whereas demand has steadily increased. The supply – demand gap, especially in the dry season, gets larger and larger over these years.



(Source: Data Provided by NEA)

Figure 2-24 Peak Supply and Demand Balance in Nepal

Due to the absence of considerable domestic hydropower capacity increase, electricity imports also increase to meet surging domestic demand. Export volume has been halted since 2011. Electricity import-export in Nepal is depicted in the following figure.



	2006	2007	2008	2009	2010	2011	2012	Year
Import	329	425	356	639	694	746	793	GWh
Export	77	60	46	75	31	4	4	GWh

(Source: IEA Energy Balance)

Figure 2-25 Electricity Import-Export in Nepal

2.4.2 Government agencies in the power sector

(1) Power Sector Agencies

The key government agencies for power sector development are as follows:

- Ministry of Energy (MOE) for policy making
- Water and Energy Commission Secretariat (WECS) for planning and research
- Department of Electricity Development (DOED) for licensing, facilitation, promotion, monitoring, and project study.
- Nepal Electricity Authority (NEA) as public utility for generation, transmission and distribution of electricity.
- Electricity Tariff Fixation Commission (ETFC) as electricity tariff regulator.

For the promotion of hydropower projects, the DOED has been designated as a Single Window with the following responsibilities:

- Issuance of survey and project licenses;
- Providing concessions and incentives;
- Assistance in importing goods;
- Assistance in obtaining land;
- Assistance in obtaining permits; and
- Approvals.

(2) Application process for generation distribution

For the development of projects with a capacity of more than 1,000 kW, a project proponent has to obtain i) Survey License to study generation survey for the project, ii) Operation License, and iii) Production License (for construction and operation of a production facility).

The project proponent will be granted a Generation License with the submission of the following documents:

- Feasibility Study Report, including;
  - Detailed description of the project;
  - Description of related transmission line to evacuate power; and
  - Approved IEE/EIA Report from the relevant Ministry.

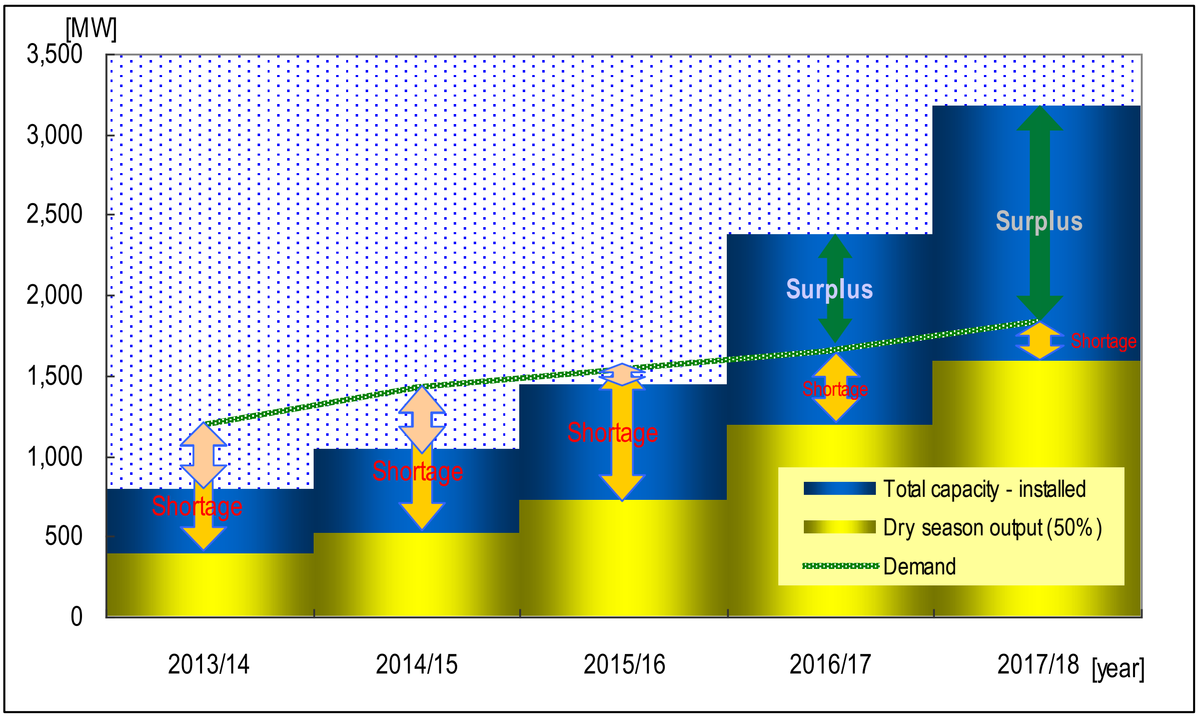
- Detailed Financing Plan, including:
  - Estimated cost of the project;
  - Financial capability of the investors in the project;
  - Commitment of the financial institutions to be involved directly in the project; and
  - Equity and debt ratio.
- Power Purchase Agreement
- Other Requirements

Once the proponent obtains the Generation License the proponent takes on the following obligations to:

- Start construction work within 1 year;
- Complete financial closure within 1 year of license's issued date;
- Submit bi-annual progress report until construction is completed;
- Undertake testing and commissioning;
- Start commercial operation; and
- Start paying royalties.

2.4.3 Electricity Supply and Demand in Nepal

Power generation capacity at FY2013/2014 end was 787MW. However, because most of the capacity (approx. 85%) is run-of-river HPP, actual power generation capacity in the dry season drops down to 250MW-300MW. On the other hand, maximum demand is estimated at 1,200MW, coinciding with the dry season. Therefore, Nepal faces chronic and severe power deficits. The deficits cannot be met by power purchases from IPPs and India, resulting in rotational forced outages by NEA. NEA is currently developing its domestic hydropower generation capacity with financial assistance from various donors. There are 11 power plants currently being developed with a capacity of 1,044MW in addition to numerous small- and medium-sized hydropower IPPs (with an aggregated capacity of up to 900MW). If these development projects are commissioned on time, by 2017, Nepal may have surplus capacity (only during the wet season) to trade with the rest of the region as the following figure indicates.



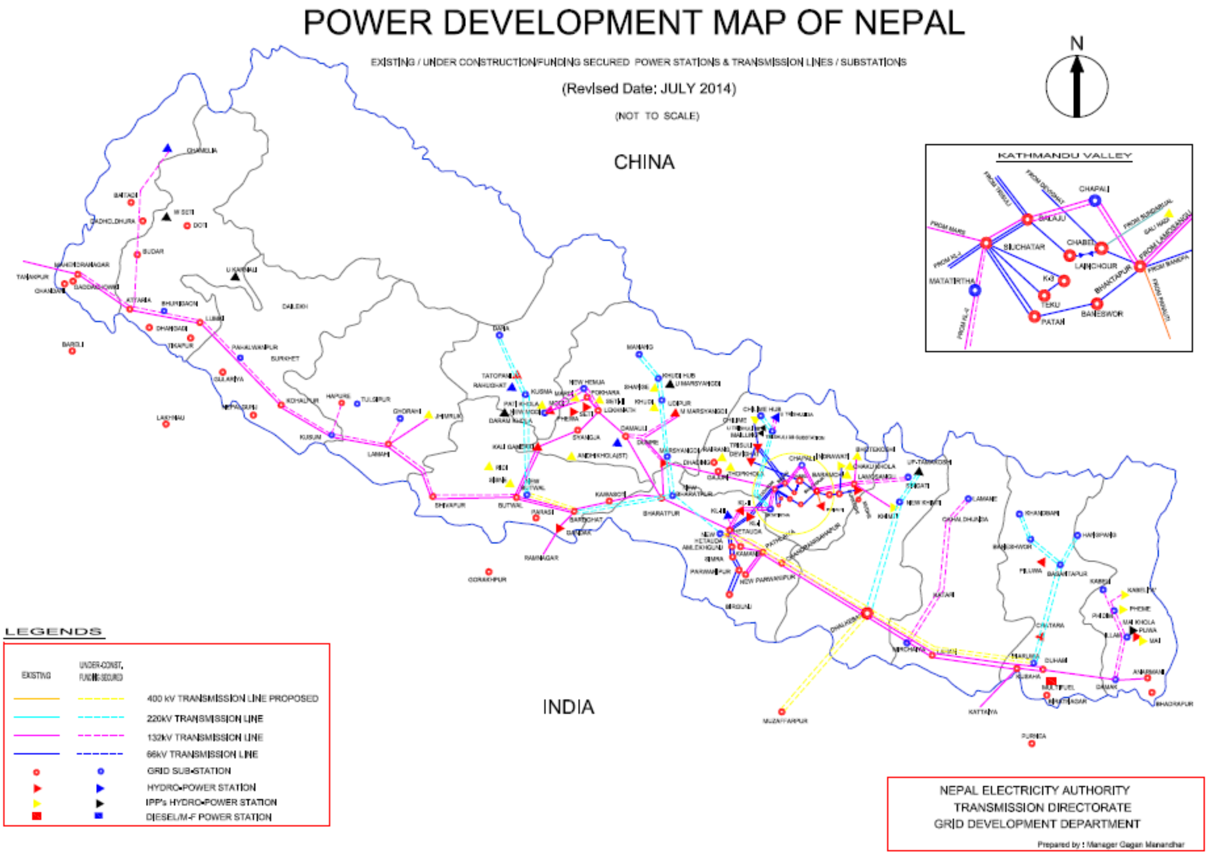
(Source: Consultant's Desktop Calculation based on Interview with NEA)

Figure 2-26 Demand and Supply Forecast in Nepal

2.4.4 Nepal Power Grid

Because very high mountains exist from east to west, the 132kV bulk system of Nepal is composed along the border with India, and the power supply line is installed from there to each hydropower plant.

The 400kV and 220kV transmission lines are under construction with the development of the hydroelectric power plants, and the first 400kV power line in Nepal is scheduled to be completed in 2014/2015.



(Source: NEA (July 2014))

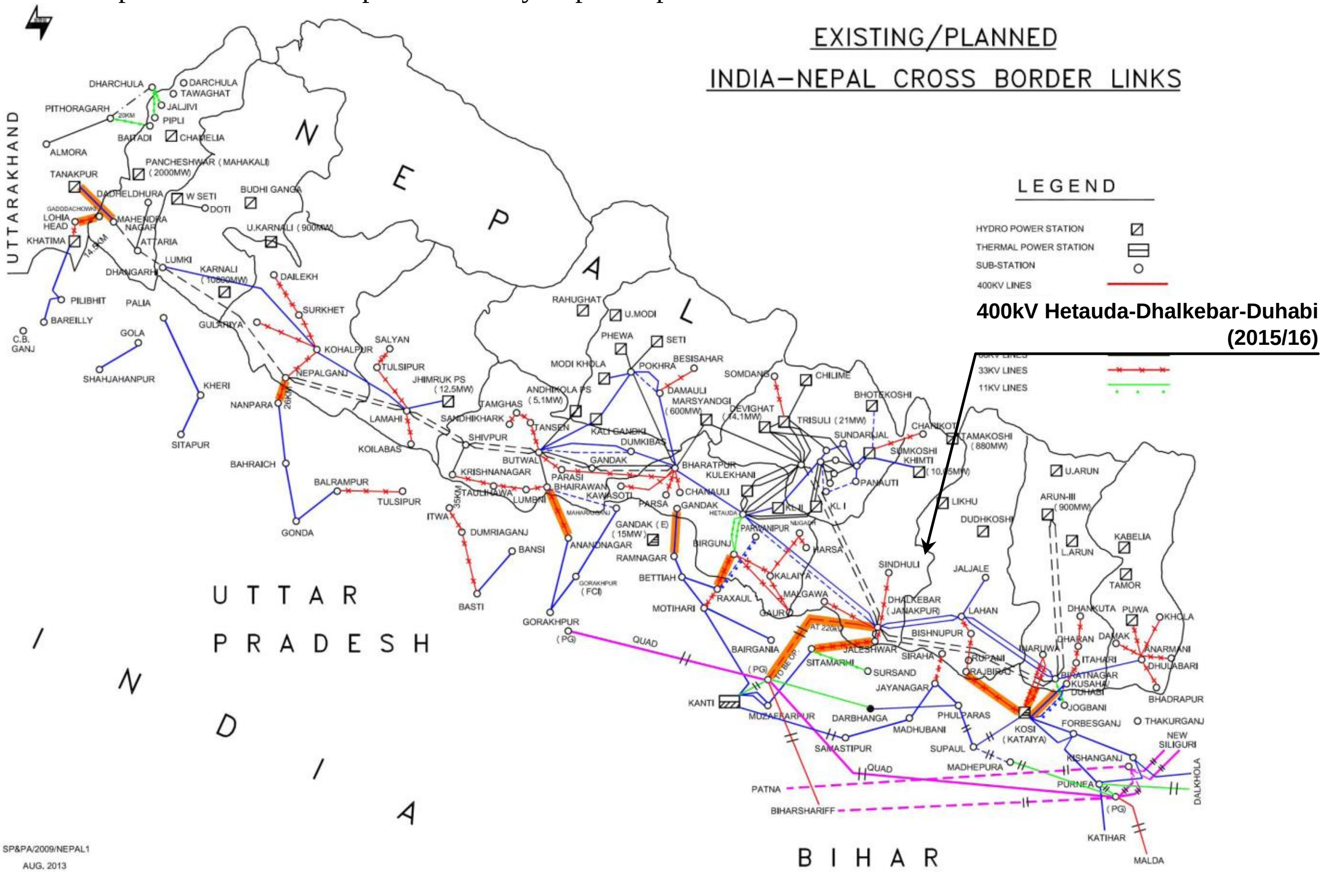
Figure 2-27 Power Grid Map of Nepal

Table 2-16 400kV Transmission Line Expansion Plan

400kV Transmission Line				
	Name of Lines	Lenth in Route (km)	Cost [M US$]	Project Completion Year
Under Construction	Dhalke - Bhitta	40	30	2014 / 2015
	Hetauda - Dhalkebar - Duhabi	285	139	2015 / 2016
Proposed	Hetauda - Butwal	190	152.63	2017 / 2018
	Lamki - Mahendra	105	84	2021 / 2022
	Butwal - Lamki	220	176	2021 / 2022
	Bardaghat - Gorakhpur	40	32	2019 / 2020
	Duhabi - Jogbani	20	16	2019 / 2020
	Dudhkosi 400kV Corridor	100	80	2022 / 2023
Total		**1,000**	**710**	

(Source: NEA (April 2014))

Electric power dealings have already been done between Nepal and India through 132kV and 33kV interconnected lines. A 400kV transmission line which interconnects between Nepal and India will commence operation to evacuate power from hydropower plants in 2017.



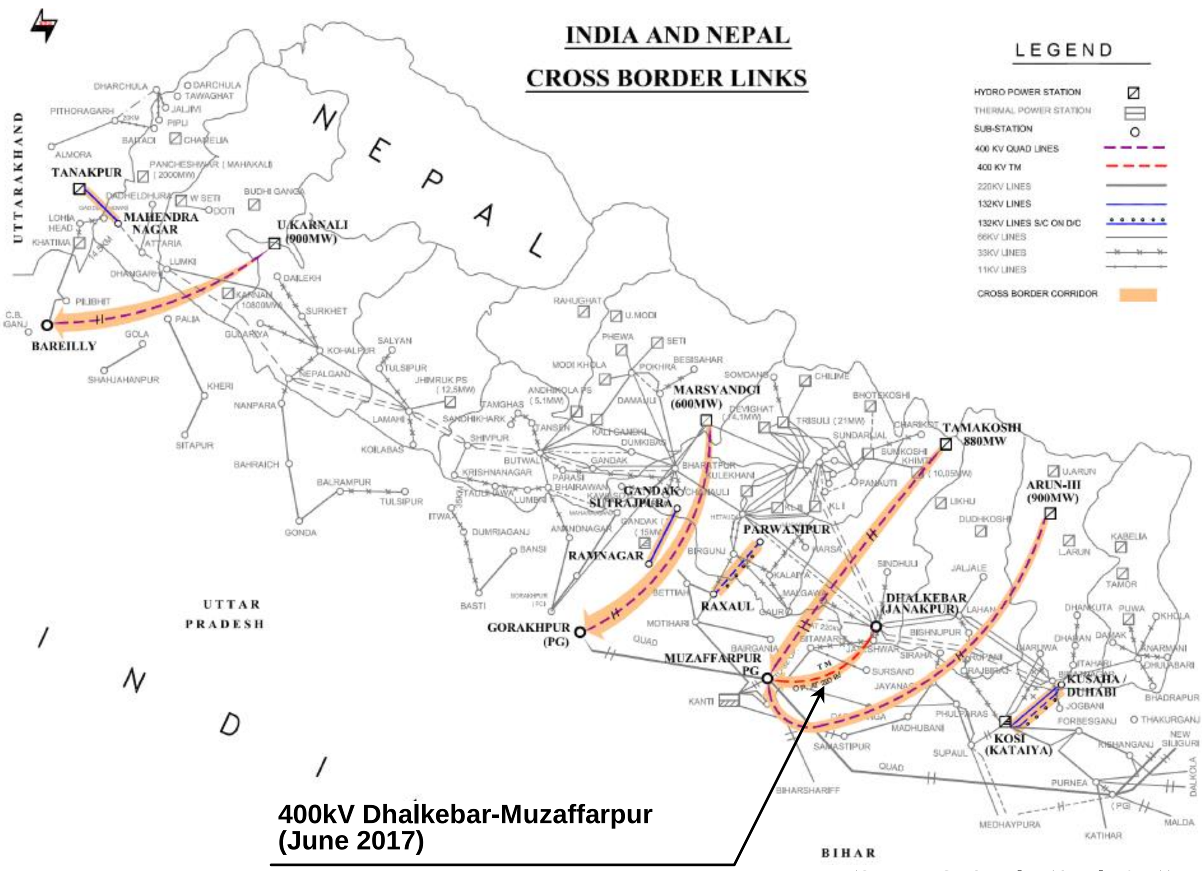
(Source: CEA India (April 2014))

Figure 2-28 Existing/Planned India – Nepal cross border links

Table 2-17 Existing Interconnections with India

Existing Interconnections with India			
Voltage Level (kV)	Transmission Link	Evacuation Cap. (MW)	Traded (MW)
132	Kusaha - Kataiya	130	80
	Gandak - Rampur	50	25
	Mahendranagar - Tanakpur	50	30
33	Kataiya - Rajbiraqj	10	8
	Raxual - Birgunj	10	10
	Sitamadhi - Jaleswor	10	8
	Nepalgunj - Nanpara	10	8
	Jayanagar - Siraha	8	8
Total		**278**	**177**

(Source: NEA (April 2014))



(Source: CEA India (April 2014))

Figure 2-29 India and Nepal cross border links

Table 2-18 Under Construction and Planned Interconnections with India

Under Construction and planned Interconnections with India			
Voltage Level (kV)	Transmission Link	Transfer Cap. (MW)	Status
400	Dhalkebar - Muzaffarpur	1,200	Under cons.
	Bardaghat - Gorakhpur	1,800	Planned
	Duhabi - Jogbani	1,800	Identified & Proposed
	Other Links	--	To be identified
Total		**4,800**	

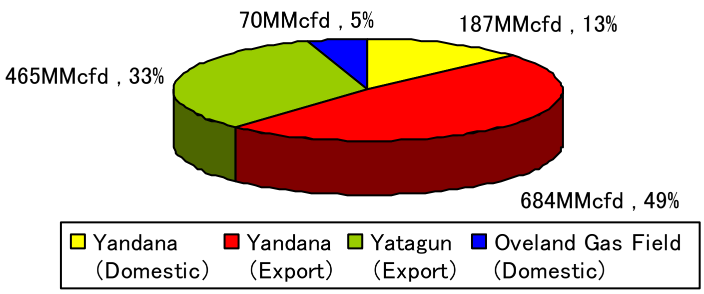
(Source: NEA (April 2014))

2.5 Myanmar

2.5.1 Energy Policy

Energy policy was revised in 2011 by the Energy Planning Department (EPD), which is a Ministry of Energy (MOE) internal organization.
There are six main goals forming the basis of Myanmar's present energy policy framework.
(1) Maintaining energy independence
(2) Promoting the wider use of new and renewable sources of energy
(3) Promoting energy efficiency and conservation
(4) Promoting household use of alternative fuels
(5) Promoting petroleum oil and natural gas development for national benefit
(6) Promoting private sector investment for the energy industry

Myanmar has abundant energy resources, particularly hydropower and natural gas. The hydropower potential of the country's rivers, which drain the four main basins of Ayeyarwaddy, Chindwin, Thanlwin, and Sittaung is estimated at more than 100GW. Proven gas reserves total 11.8 trillion cubic feet (tcf) with huge potential for discovery. Offshore gas is the country's most important source of export revenues, currently supplying Thailand.



(Source: Ministry of Energy)

Figure 2-30 Export and Domestic Use of Natural Gas

Table 2-19 Offshore Gas Fields

Gas Field	Operator	Partner	Export Volume (MMcfd)	Domestic (MMcfd)	Export to	Commencement of Production
Yadana	Total (France)	Chevron,PTTEPI MOGE	684	187	Thailand	1999
Yetagun	Petronas (Malaysia)	MOGE、PTTEP Nisseki Myanmer Sekiyu Kaihatsu	465	0	Thailand	2000
Shwe	DAEWOO International (Korea)	Kogas,ONGC-Videsh, GAIL India	400	100	China	2013
Zawtika	PTTEP (Thailand)	MOGE	240	60	Thailand	2013

(Source: Ministry of Energy)

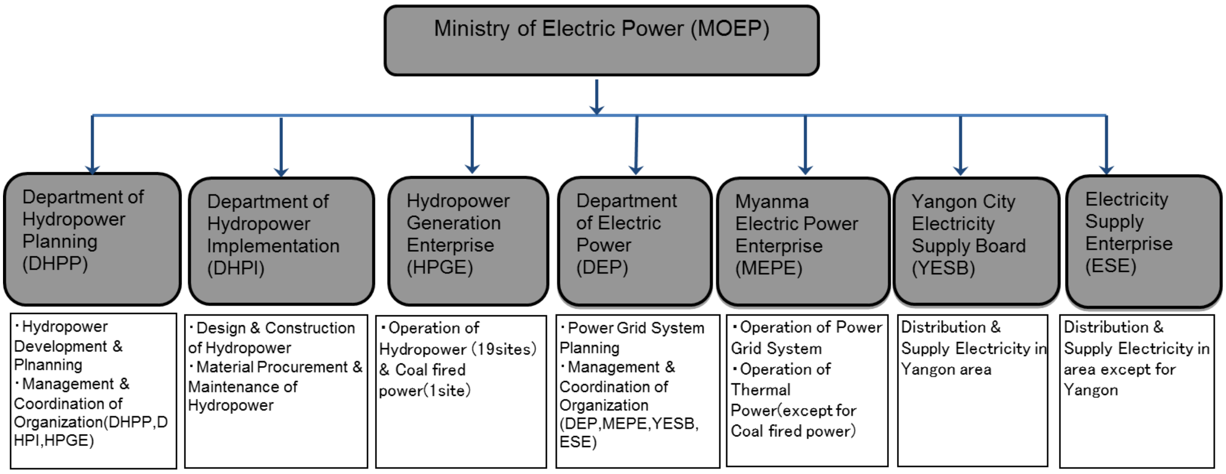
Driven by the suspension of economic support, after 1989, Myanmar was planning to develop power stations efficiently with limited funds to resolve and alleviate power shortages. After a large scale offshore gas field was discovered in 1992, gas turbines that can be constructed in a short period were utilized and then converted into CCGT to minimize the time of blackouts. During that time, hydro power stations were developed in order to resolve power shortages. Accordingly the main source of

power was gas turbines and CCGT in the 1990's. However, exporting natural gas to Thailand was prioritized for the acquisition of foreign currency, which limited the supply for internal use.
Hydro power stations were developed during the 1980's and 1990's. But most of them were from 10MW to 50MW medium sized class hydro power stations.
The acquisition of foreign currency from exporting natural gas increased the investment fund, along with the commencement of economic support from China, leading to the development of large scale hydro power stations.
The main development of power continues to be hydro power utilizing the rich water resources and the development of natural gas is also expected. The Ministry of Electric Power and Ministry of Agriculture and Irrigation are promoting the development of hydro power stations with a background of Chinese funds.
The basic policies of power development in Myanmar are as follows

(1) In the short term, promoting development of domestic water resources in order to resolve the limitation of supply
(2) In the long term, promoting development of power stations of more than the internal demand level and exporting surplus power to neighboring countries

2.5.2 Organization of Power Development

The regulatory framework for the power sector in Myanmar includes the Electricity Act of 1948 (as amended in 1967), the Myanmar Electricity Law (1984), and the Electricity Rules (1985). The power sector in Myanmar was the responsibility of two ministries: MOEP1 and MOEP2 until a merger in September 2012. The present organization and functions of MOEP are provided in Figure 2-31.



(Source: JICA Survey Team)

Figure 2-31 Organization Structure of Ministry of Electric Power

DHPP plans hydropower projects to be implemented by MOEP itself, by local provincial enterprises, or by joint ventures with foreign investors. DHPI has four institutes responsible for design, investigation, and mechanical work, and seven engineering construction companies capable of undertaking large hydropower projects. HPGE operates and maintains all of MOEP's hydropower stations, and participates in the operation and maintenance of power plants under joint ventures. HPGE also operates a coal-fired power plant.
DEP's main function involves power system strategic planning. MEPE is responsible for the development, operation, and maintenance of the transmission network, and the operation and maintenance of gas-fired power plants, including gas turbines. YESB is responsible for the supply of electricity to consumers in Yangon City. ESE covers all 13 states and divisions in the rest of the

country, including off-grid generation and distribution; it is also responsible for planning, implementing, and operating off-grid mini-hydropower and diesel stations. Correspondingly, YESB and ESE also implement system improvement and expansion of distribution systems.

2.5.3 Demand & Supply

Myanmar has chronic shortages in the supplying of electricity; however, the gap between demand and supply capacity is shrinking year by year.
If there is no additional generation from new power plants, the power shortage will be about 220 MW (10% shortage) in the Dry Season. According to an MOEP presentation, thermal power is the best solution for reducing power shortages because it does not depend on the season and short construction period. Therefore, the priority is to establish gas engine power plants and gas turbine power plants.

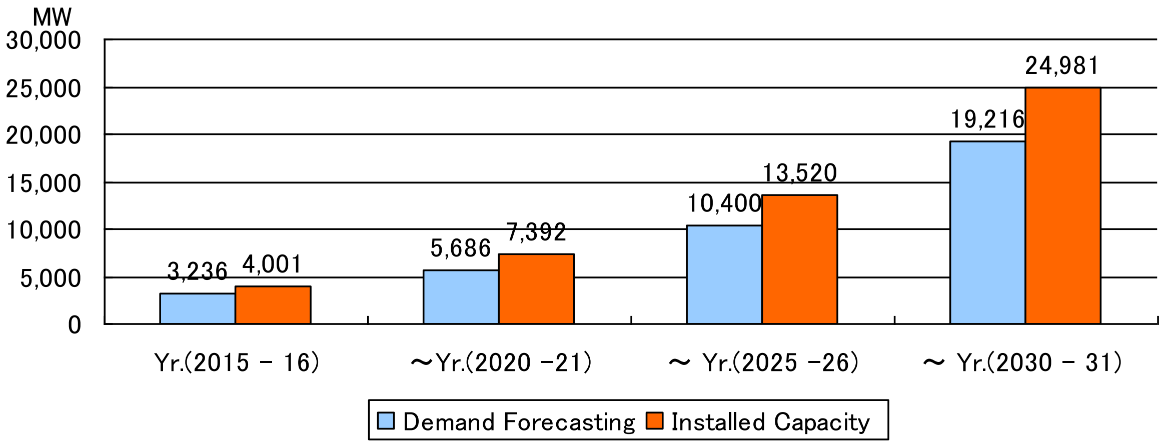
Table 2-20 Short term demand & Supply Forecast

(MW)

Description	2013		2014		2015		2016	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Hydro Generation	1301	2017	1259	2289	1341	2289	1346	2319
Thermal Generation	540	492	1076	1182	1572	1784	2153	2089
Total Generation	1841	2509	2335	3471	2913	4073	3499	4408
Demand Forecast	2060	1957	2370	2252	2725	2589	3130	2974
Difference	(-) 219	(+) 552	(-) 35	(+) 1219	(+) 188	(+) 1484	(+) 369	(+)1434

(Source: Ministry of Electric Power "Present & Future Power Sector Development in Myanmar 27-2-2013")

As Figure 2-32 shows, Myanmar has surplus supply from planned hydro power generation and is going to export electricity to neighboring countries in the longer term.

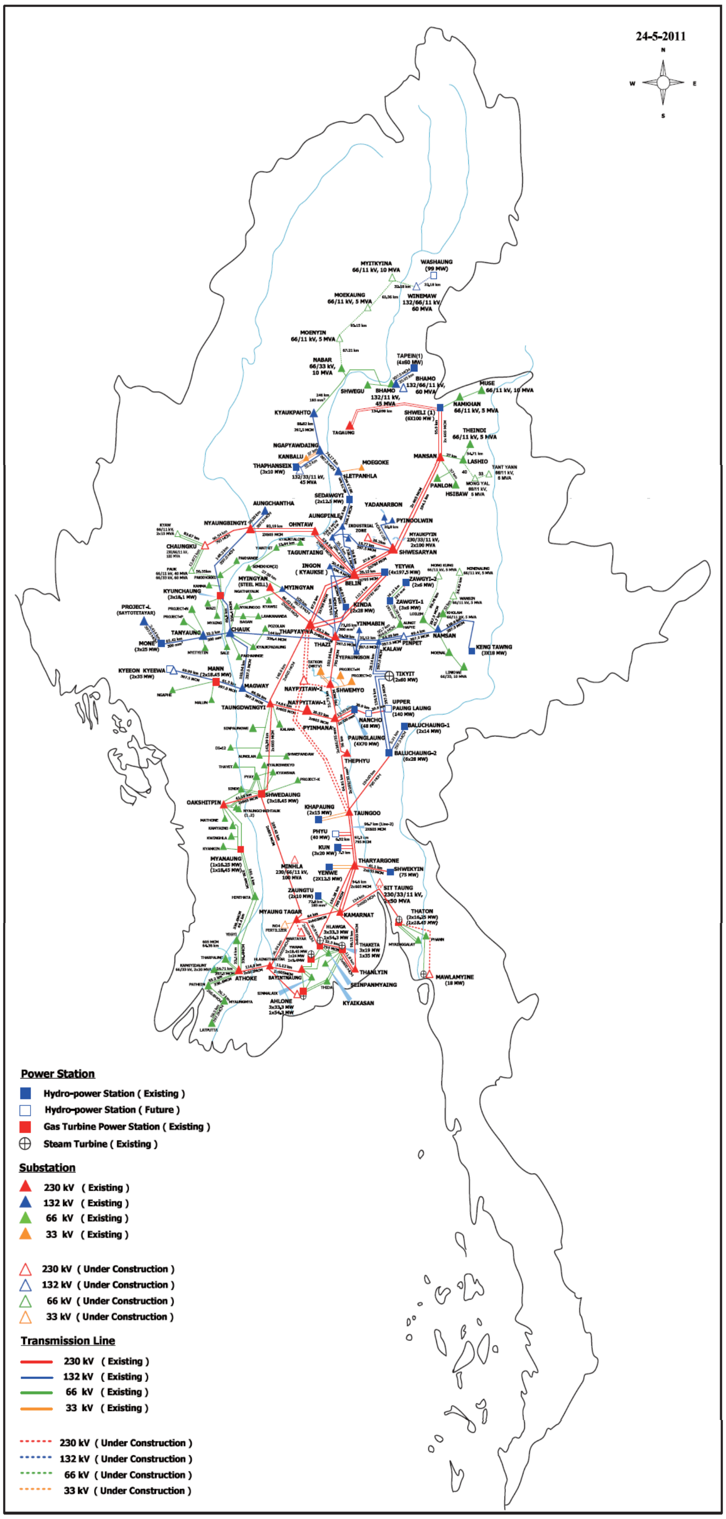


(Source: Ministry of Electric Power "Present & Future Power Sector Development in Myanmar 27-2-2013")

Figure 2-32 Long term demand & Supply Forecast

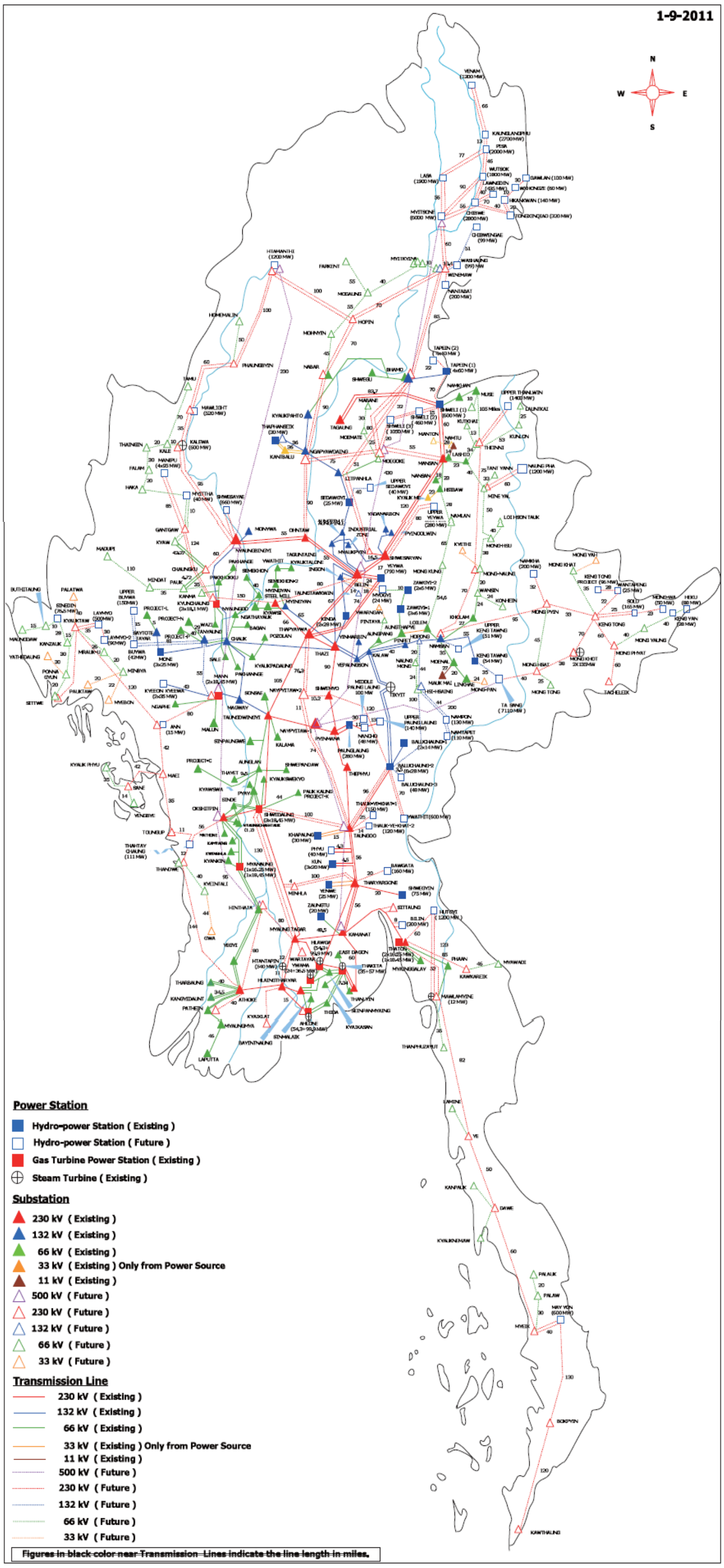
2.5.4 Myanmar Power Grid

As for the international interconnection system of Myanmar, there are neither interconnection lines nor a concrete plan, though the government of Myanmar has an idea to connect its system with Thailand's system in the future.



(Source: JEPIC (Oct. 2012))

Figure 2-33 Power Map of Myanmar



(Source: JEPIC (Oct. 2012))

Figure 2-34 Power System expansion plan

Chapter 3 Interconnection Lines

3.1 Activities towards Regional Power Interconnection

This section summarizes movements toward regional power interconnection in South Asia and around the Bay of Bengal, where Bangladesh is located.

(1) SAARC (South Asian Association for Regional Cooperation)

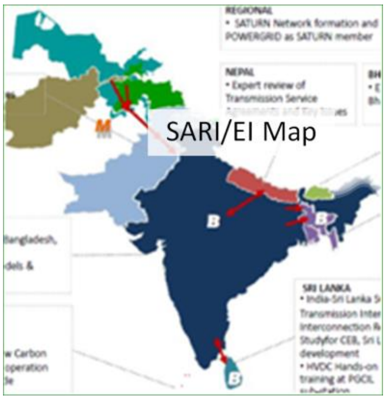
SAARC, found in 1985, established the SAARC Energy Centre (SEC) in Islamabad in order to create an energy ring in the region. Since then, SEC has carried out activities associated mainly with the promotion of regional energy trades, energy conservation to reduce fuel imports, and rural electrification for poverty reduction. In May 2012, SAARC proactively undertook activities such as the organization of a workshop for key policy-making officials on cross-border electricity trading in the region (held in Bhutan in May 2012) to enhance regional power interconnection. In the 18th SAARC Summit, held in November 2014 in Kathmandu, all participating countries signed the SAARC Framework Agreement for Energy Cooperation (Electricity), which ensures power trading through grid connectivity and integrated operation of the regional power grid (SAARC Grid).

(Soure: MOFA, Japan)

Figure 3-1 SAARC Map

(2) SARI/EI (South Asian Regional Initiative for Energy Integration)

The United States Agency for International Development (USAID) has proactively assisted eight South Asian countries (India, Bangladesh, Nepal, Bhutan, Sri Lanka, Pakistan, Afghanistan and Maldives) with the promotion of cross-border energy trades in the region. USAID nominated Integrated Research and Action for Development (IRADe) as a project coordinator for the fourth (final) program between 2012 and 2017, comprising Task Force 1 (TF-1) Harmonization of Policy, Legal and Regulatory Issues, TF-2 Advancement of transmission system interconnection, and TF-3 Establishment of South Asian Regional Electricity Market. In October 2013, USAID organized an international conference on cross-border electricity trades in the course of the SARI/EI program in Delhi.

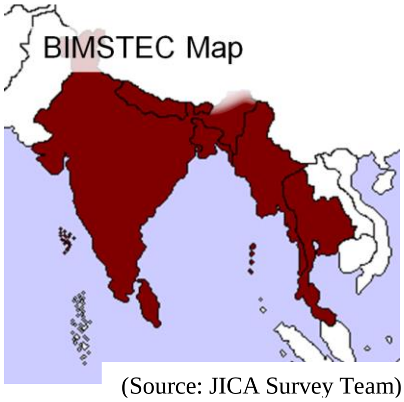


(Source: SARI/EI)

Figure 3-2 SARI/EI Map

(3) BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation)

BIMSTEC was formed in 2004 by adding Nepal, Bhutan and Myanmar to BIST-EC (Bangladesh, India, Sri Lanka and Thailand Economic Cooperation), which was formerly established (in 1997) by four key countries facing the Bay of Bengal. BIMSTEC promotes economic cooperation at various levels among member countries, focusing on 6 key sectors, Trade and Investment, Transport and Telecommunication, Energy, Tourism, and Fisheries. In its energy ministers' conference in 2005, a Memorandum of Understanding (MOU) on regional power trades, interconnection, hydropower development and energy security was signed and BIMSTEC Energy Center (BEC) was established. In Dhaka in 2012 and in Delhi in 2013, BIMSTEC set up a task force on regional power trading and member countries have been arranging MOUs on power interconnection and regional power trades since then.



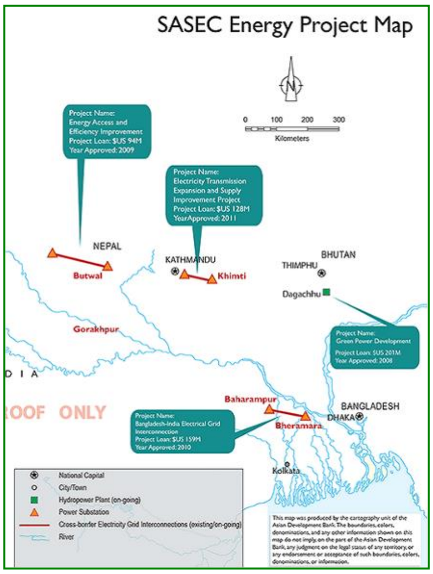
(Source: JICA Survey Team)

Figure 3-3 BIMSTEC Map

(4) SASEC (South Asia Sub-regional Economic Cooperation)

The Asian Development Bank (ADB) started up a SASEC program targeting six countries, Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka, and has increased its presence as it leads regional electricity trading in the region through the operation of the Energy Working Group (EWG) of SASEC. In recent years (after 2010), responding to Research Report on SAARC Regional Power Trade, ADB completed Technical Assistance (TA) on the South Asia Regional Power Exchange Study (SARPES) in 2013 and is now implementing TA on SASEC Cross-border Power Trade Development. The ongoing TA is expected to formulate a cross-border power interconnection plan in the region and information/know-how sharing on regional power trading among member countries.

In addition, ADB plans to launch one other TA (No.8658: South Asia Economic Integration Partnership - Study on Power Trading In Bangladesh and Nepal) within 2014. According to a procurement notice, TA with a budget of USD 1 million is envisaged in its scope of work to i) undertake a feasibility study on the establishment of power trading companies in both countries, ii) develop a database for interconnection plans from Bangladesh and Nepal to the rest of the SASEC member countries, iii) support the Bangladeshi government officials in networking with counterparts in SASEC countries.



(Source: SASEC Home Page)

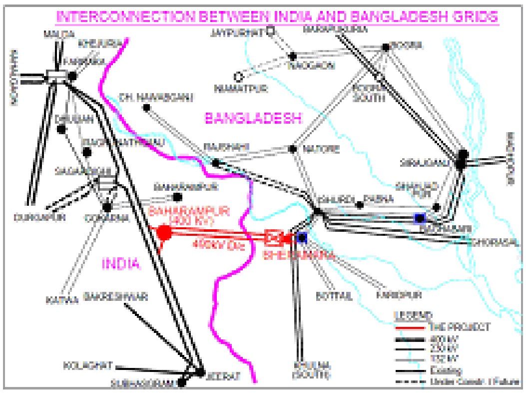
Figure 3-4 SASEC Energy Project Map

(5) BBIN (Sub-regional Grouping of Bangladesh, Bhutan, India and Nepal)

BBIN is a sub-regional coordination framework, consisting of Bangladesh, Bhutan, India and Nepal. BBIN holds biannual Joint Working Groups (JWGs) where key officials from each member country facilitate and implement quadrilateral agreements mainly on water resource management, connectivity of power grids, multi-modal transport, freight and trade infrastructure. In BBIN's 2nd JWGs held in New Delhi in January 2015, all countries agreed on joint efforts to explore the harnessing of water resources including hydropower and to exchange lists of potential future hydropower and power projects to be undertaken jointly involving at least three countries on an equitable basis.

(6) Latest Developments in Cross-Border Electricity Interconnection in Bangladesh

Bangladesh and India inaugurated the first 400kV cross-border power interconnection with a 500MW back-to-back high-voltage direct current (HVDC) system between Bheramara (Bangladesh) and Baharampur (India) in 2013. The transmission interconnection has an option to enhance the power flow up to 1,000MW in the future in line with the regional power trade plan in the current Power System Master Plan (PSMP) of Bangladesh. Apart from power imports (1,000MW by 2025) from Baharampur, there are four other options listed in the PSMP: Myanmar – Bangladesh (500MW), Palatana (Tripura) – Comilla (250MW), Silchar (Assam) – Fenchuganj (750MW), Alipurduar (West Bengal) – Bogra (500MW), Kishanganj (Bihar) – Bogra (500MW) and Myanmar – Chittagong (500MW).



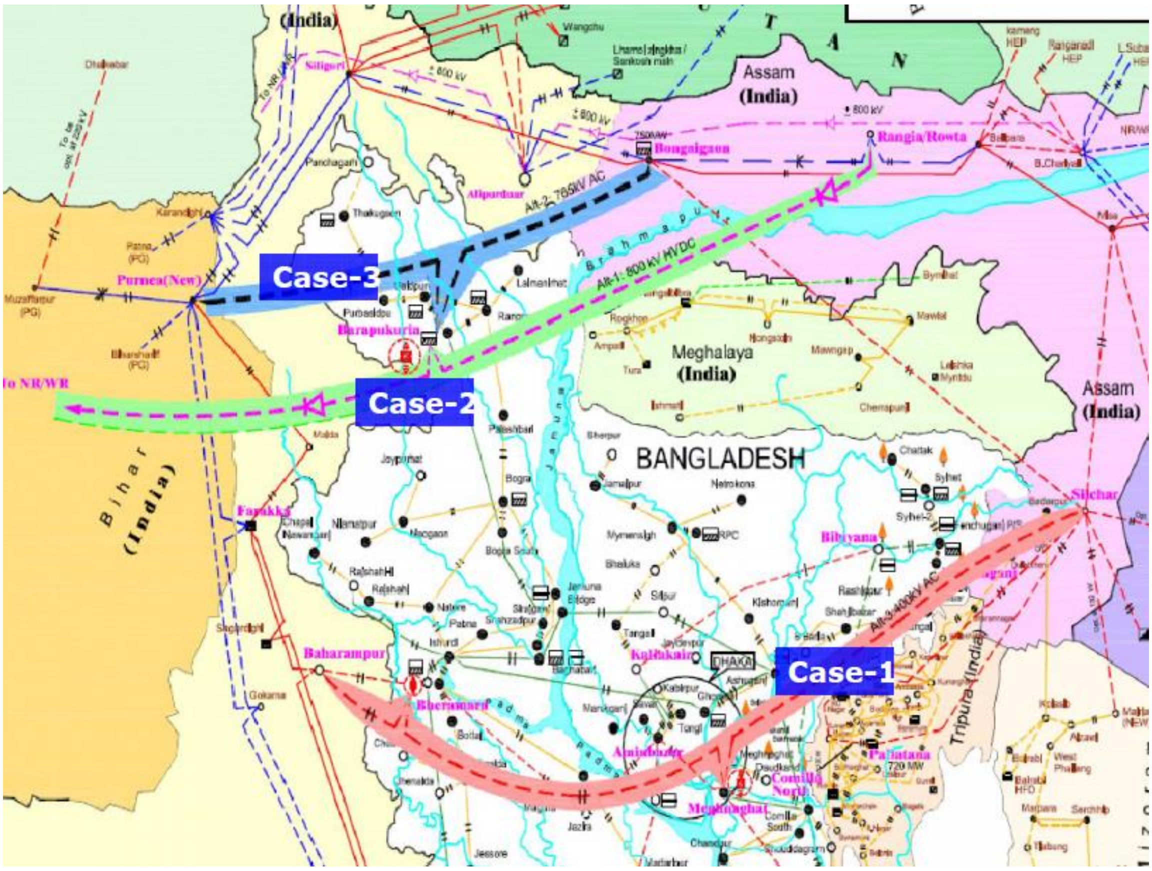
(Source: BGCB)

Figure 3-5 Bangladesh – India Link

In the 4th Joint Steering Committee meeting on the power sector between Bangladesh and India held in Delhi on 28th February 2012, a Joint Technical Team (JTT) was constituted to explore the possibility of future interconnection between India and Bangladesh. The JTT formulated a report on future power interconnection options, and presented this in the 7th Joint Steering Committee Meeting in April 2014. The JTT report discusses three new regional interconnection options from Assam/Tripura to West Bengal/Bihar via part of the Bangladeshi territory, as follows:

- **Case-1:** Silchar (Tripura) – Baharampur (West Bengal) 400kV Line via Meghnaghat HVDC back-to-back station dropping of 500MW to Bangladesh;
- **Case-2:** 800kV HVDC 6,000MW Bi-pole Line from Rangia/Rowta (Assam) to North East/West Region of India via Jamalpur or Barapukuria dropping 500-1,000 MW to Bangladesh by a HVDC back-to-back station; and
- **Case-3:** 765kV HVAC Line from Bongaigaon (Assam) to Purnia (Bihar) via Jamalpur or Barapukuria dropping 500-1,000MW to Bangladesh by a HVDC back-to-back station.

The following map shows these three interconnection option cases.



(Source: JTT Report)

Figure 3-6   JTT Bangladesh – India Interconnection Options

Among the aforementioned three options, the two countries agreed upon Case-2 with ±800 kV HVDC and decided to proceed with the completion of a Detailed Project Report (DPR) by November 2015. This plan (Case-2) is aimed at developing abundant hydropower potential areas in the North Eastern States in India and Bhutan and mainly evacuating the generated energy to central India. It is envisaged to avoid passing through the Chicken Neck area, where the Indian territory becomes extremely narrow, when the transmission route crosses into Bangladesh. On the other hand, Bangladesh can tap energy of up to 1,000 MW by installing an AC-DC converting station around Barapukuria. Therefore, this plan can benefit the two countries at the same time.

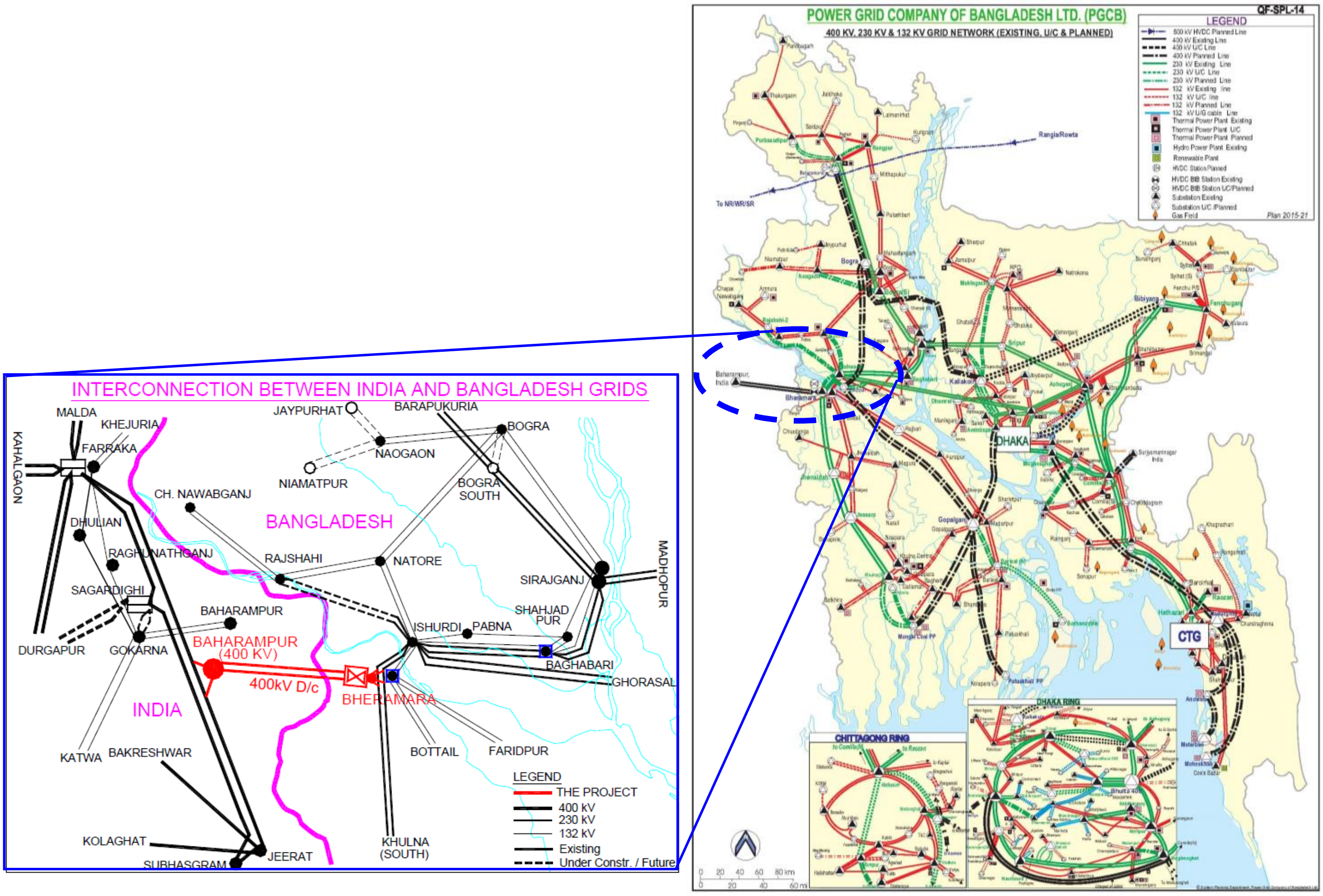
In June 2015, Bangladesh and India published a joint declaration, following a summit meeting between Prime Ministers from each country. Among other things, both PMs welcomed the consensus between Bangladesh and India to evacuate power from the North-eastern region of India (Rangia/Rowta) to Muzaffarnagar of India through Bangladesh, constructing a ±800 kV, 7000 MW HVDC multi-terminal bi-pole DC grid line with suitable power tapping points at Barapukuria in Bangladesh. Prime Minister Modi agreed in principle to consider Bangladesh's request to provide adequate power from this line for Bangladesh keeping in view the grid security of both countries. Noting Bangladesh's interest in importing power in the BBIN framework, the Indian PM agreed to favorably consider such imports subject to grid security, transmission, interconnection and the applicable laws, rules and regulations of the respective countries.

3.2 Bilateral Interconnection with India

3.2.1 Cross-Border Interconnections between India and Bangladesh

(1) Existing interconnection between Bheramara (Bangladesh) and Baharampur (India)

(a) Geographical Map

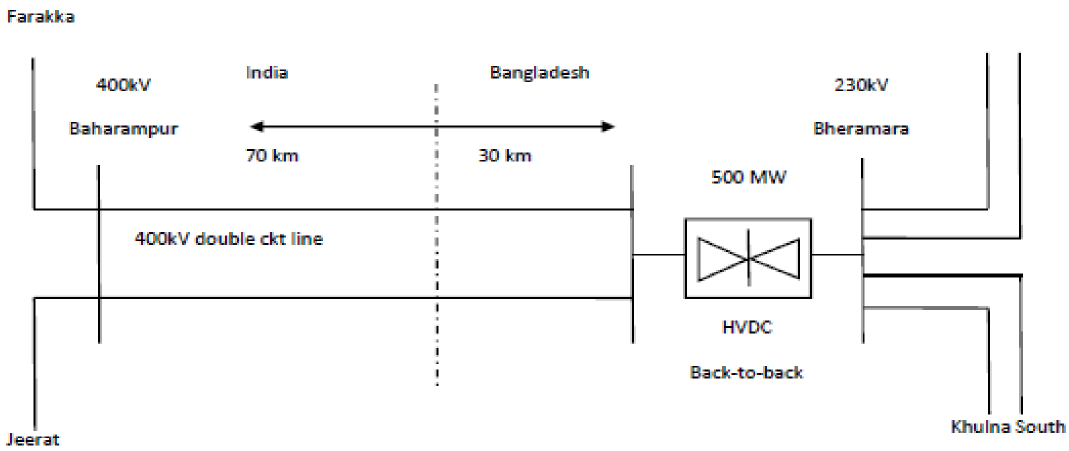


(Source: SAARC Committee)

(Source: PGCB Home Page)

Figure 3-7 Geographical Map around the Existing Interconnection between India and Bangladesh

(b) Schematic Diagram



(Source: JTT report)

Figure 3-8 Schematic Diagram of Existing 400kV Interconnection

(c) Main Features

- 400kV double circuit, 500MW HVDC Back-to-Back station at Bheramara (Bangladesh)
- Completed in Sep. 2013
- Plan to upgrade to 1000MW in 2018

Table 3-1 Features of Existing 400kV Interconnection

Objective:	(i) To Facilitate exchange of electricity between Bangladesh & India. (ii) To establish a Grid interconnection with India. (iii) To minimize the power crisis in Bangladesh to some extent.		
Project cost:	Local 81.6 MUS$, Foreign 111.06 MUS$		
Financed by:	ADB	Contractor Name:	

(Source: PGCB Website)

(d) Status of Power Flow via Interconnection

Table 3-2 Monthly Maximum Power Flow

Unit: MW

2013	2014									
Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
470	481	476	472	467	460	454	442	422	449	455

(Source: PGCB Monthly Reports)

(e) O&M

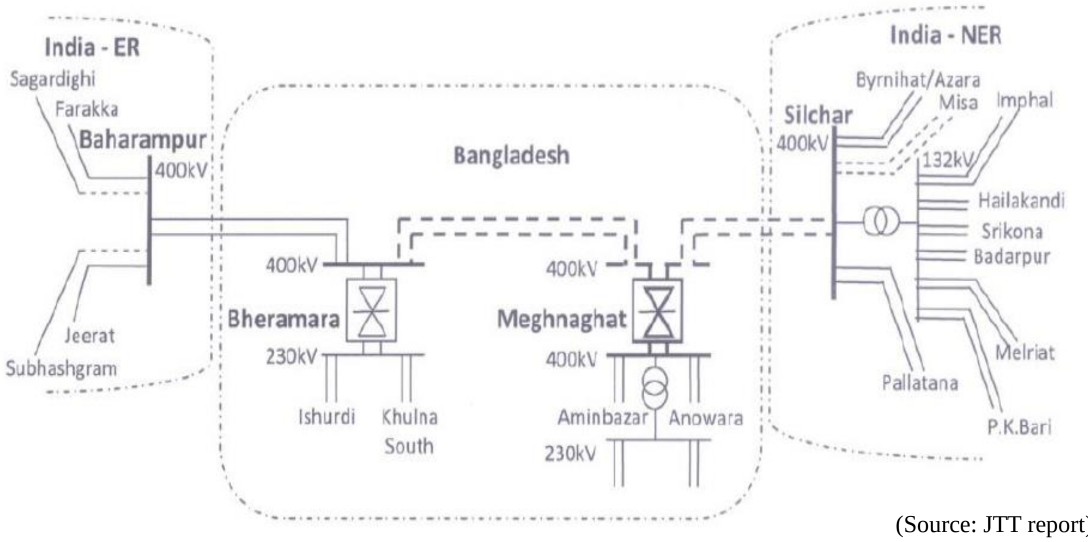
Operation and Maintenance are shared by India and Bangladesh across the border.

(2) Three Potential Cross Border Interconnection Options as per JTT (Joint Technical Team) of India and Bangladesh

Three options are being studied between India and Bangladesh as shown in Figure 3-6. Schematic diagrams and the main features of the three options are shown below.

(a) Case-1: Silchar (India: NER) – Meghnaghat/Bhulta (Bangladesh) – Bheramara (Bangladesh)

<Schematic Diagram>



(Source: JTT report)

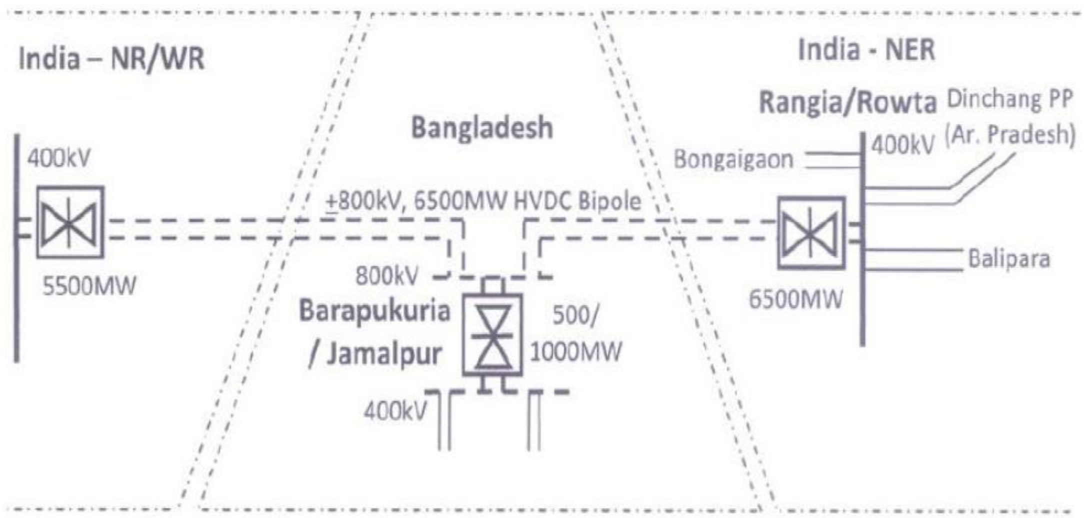
Figure 3-9 Schematic Diagram (Case 1)

<Main Features>

- 400kV AC double circuit
- 500/1000 MW HVDC Back-to-Back Station at Meghnaghat/Bhulta (Bangladesh)

(b) Case-2: Rangia/Rowta (India: NER) - Barapukuria (Bangladesh) – India:NR/WR/SR

<Schematic Diagram>



(Source: JTT report)

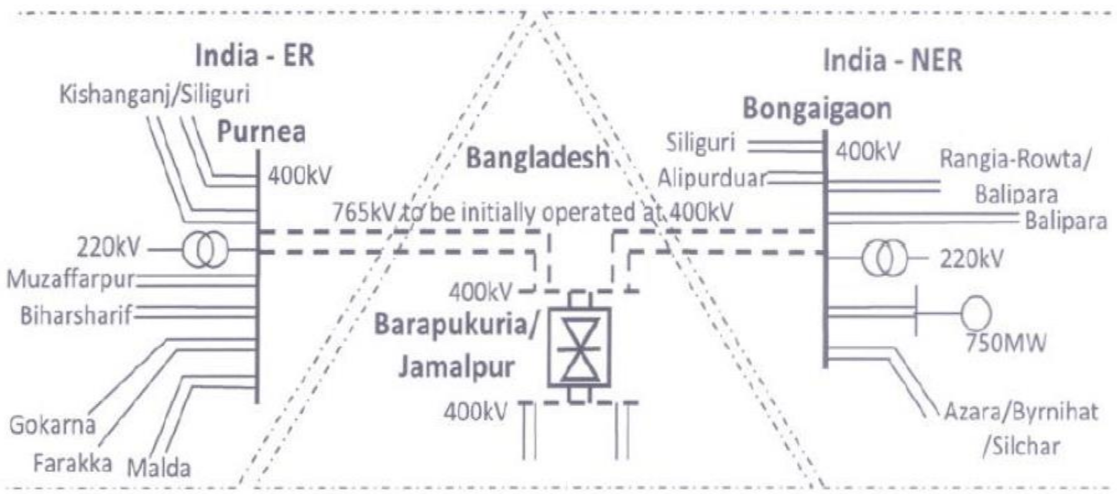
Figure 3-10 Schematic Diagram (Case 2)

<Main Features>

- +/- 800kV 6,500MW bi-pole multi-terminal HVDC
- +/- 800kV terminal station at Barapukuria/Jamalpur (Bangladesh)

(c) Case-3: Bongaigaon (India: NER) – Jamalpur/Barapukuria (Bangladesh) – Purnea (India: ER)

<Schematic Diagram>



(Source: JTT report)

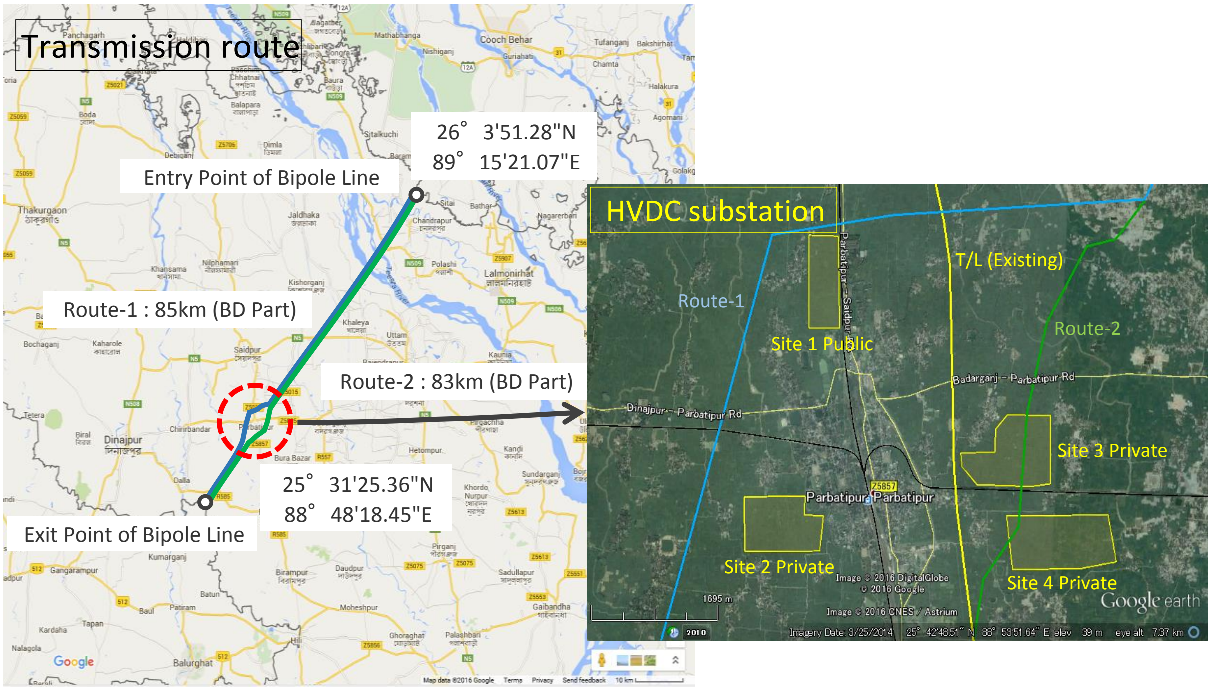
Figure 3-11 Schematic Diagram (Case 3)

<Main Features>

- 765kV AC double circuit (initially may be operated at 400kV)
- 500/1000MW HVDC Back-to-Back station at Barapukuria/Jamalpur (Bangladesh)

According to the JTT Report (March 2014), obtained in the 1st field survey, the construction plan for international tie-line is found to be being advanced steadily between India and Bangladesh. In addition, it was found that PGCB is promoting concrete action for Case-2 to be completed by 2021.
It should be noted that, according to interviews with PGCB, Case-1 is very low priority among the three options, because the transmission line route is very close to the city of Dhaka (densely populated area). Furthermore, Case-3 is the alternative to Case-2, if it is delayed.

In the Case-2 plan, as shown in Figure 3-12, the transmission route in Bangladesh territory (refer to the left of the figure) and four alternative candidate points to install the 1000MW HVDC terminal equipment (AC-DC converter) have already been researched fully (refer to the right of the figure).
In addition, plans for 400kV transmission lines (Barapukuria - Bogra - Kaliakor) to transmit power to the Dhaka region have also been researched in parallel.



(Source: PGCB)

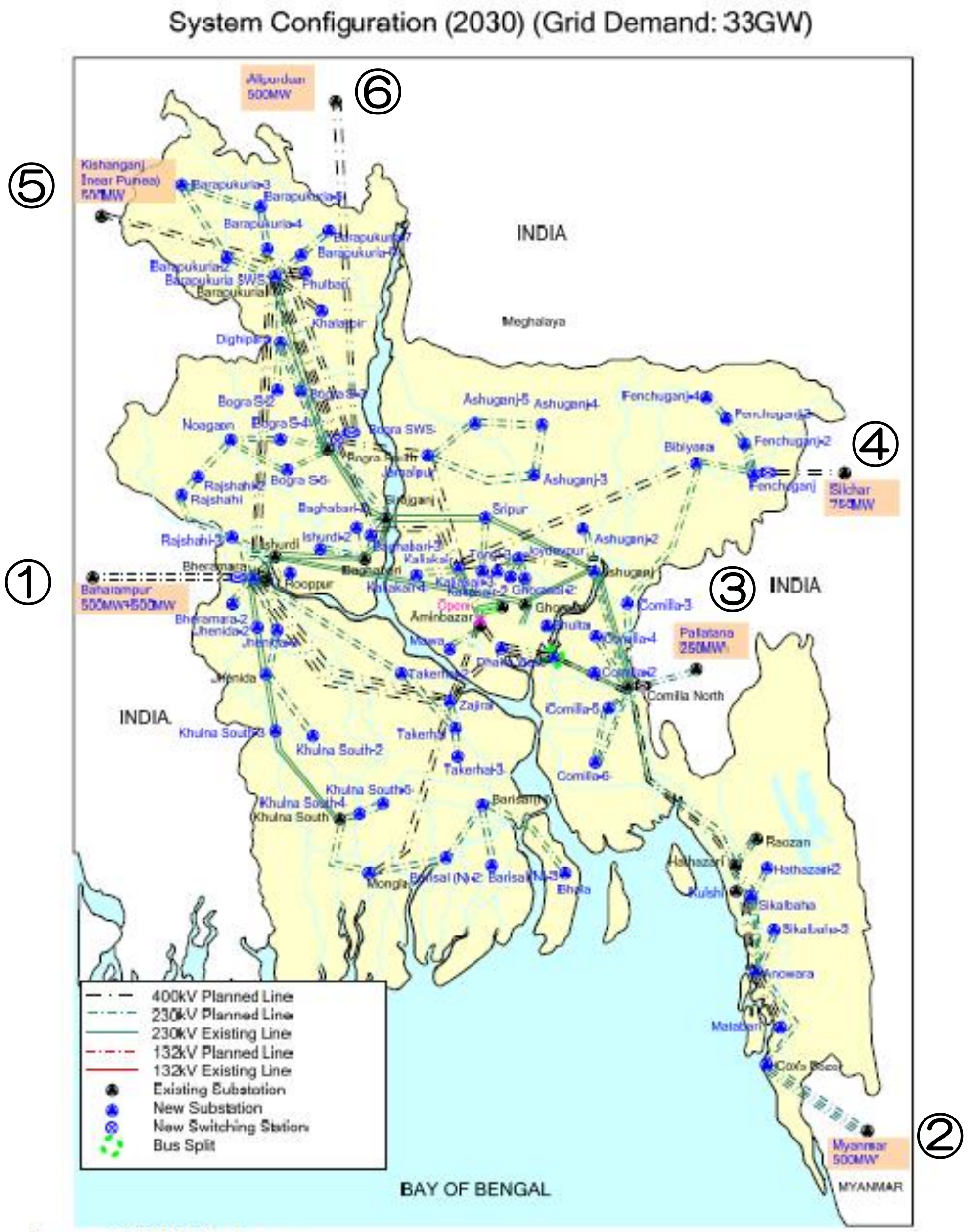
Figure 3-12 Transmission Route in Bangladesh Territory

The unresolved matters for Case-2 are as follows:

- Bangladesh has the right to receive 1000MW of power from the tie-line, but specific power plants are not determined as of now. It is left to individual transactions between developers and power companies.
- Burden rates of construction cost and investors have not been decided yet.
- O & M implementation company is also pending.

(3) Interconnection Plan in Master Plan 2010

The master plan corresponding to 33GW of system scale is shown in PSMP2010 of Bangladesh. In the report, six interconnection points with other countries, that is, one point with the Myanmar system and five points with the India system, and interconnected capacity of 3,500MW (about 10% of the whole demand) are proposed. The electric power of hydropower plants from Nepal and Bhutan is assumed to be imported through the Indian system.



Source: PSMP Study Team

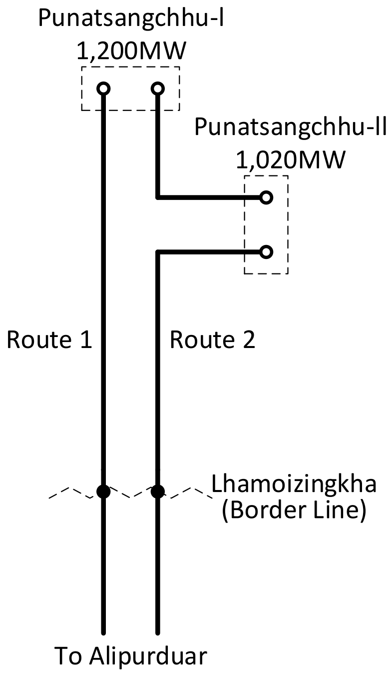
Figure 3-13 Power Grid Map of Bangladesh at 2030 (PSMP2010)

Table 3-3 Power System Expansion Plan at 2030 (Overall System)

Name of Interconnection	Power Import (MW) by Year			
	2015	2020	2025	2030
① Bheramara Bahrampur	500	500	1,000	1,000
② Myanmar Bangladesh	0	500	500	500
③ Palatana Comilla	0	0	250	250
④ Shilchar Fenchuganj	0	0	750	750
⑤ Kishanganj Bogra (Hydro Power from Nepal)	0	0	500	500
⑥ Alipurduar Bogra (Hydro Power from Bhutan)	0	0	500	500
Total	**500**	**1,000**	**3,500**	**3,500**

3.2.2 Cross-Border Interconnections between India and Bhutan

Interconnected transmission lines between India and Bhutan have been constructed in order to transmit the power from the large-scale hydropower plants developed in Bhutan to India. A 220kV transmission line between Chhukha-Birpara was constructed when the Chhukha hydropower was constructed, and a 400kV transmission line between Tala-Siliguri was constructed when the Tala hydropower was constructed, as shown in Figure 2-11.
Moreover, a 400kV transmission line between Punatsangchhu-Alipurduar is under construction because it supplies the power from the capacity 1,200 MW of Punatsangchhu-1 and 1,020 MW of Punatsangcchu-2 hydro power plants to India.



Country	Structure	Construction Maintenance Operation	Project Cost
Bhutan	400kV Double Circuit ACSR Twin Moose 93 km, 2 Route	BPC	5.8 [B Nu]
	Route 1 : Punatsangchhu-I - Lhamoizingkha Route 2 : Punatsangchhu-I - Lhamoizingkha via Punatsangchhu-II		
India	400kV Double Circuit ACSR Quad Moose 45 km, 1 Route	PGCIL	No data

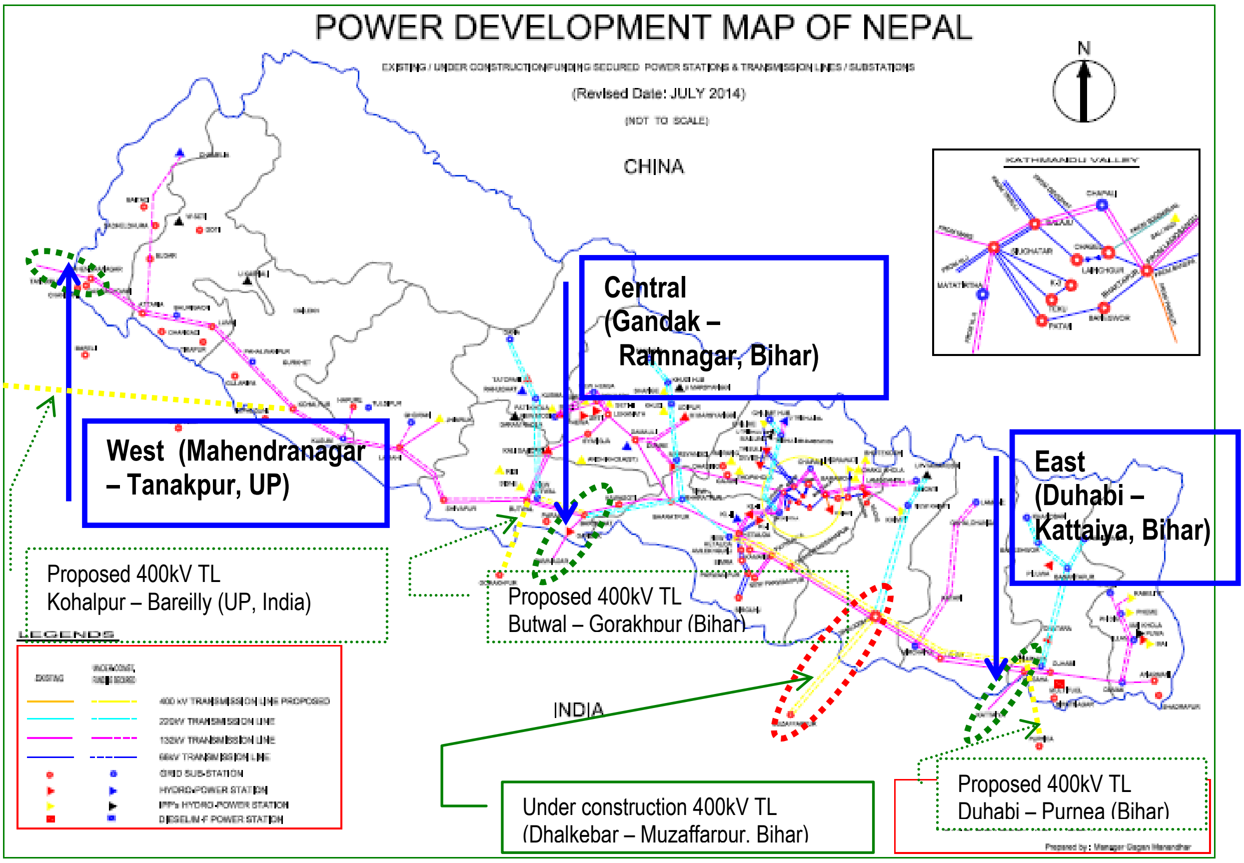
(Source: JICA Survey Team)

Figure 3-14 400kV Transmission Line between Punatsangchhu - Alipurduar

Photo 3-1 400kV Transmission Line in Bhutan (Under Construction)

3.2.3 Cross-Border Interconnections between India and Nepal

Since 1971, India and Nepal have committed to power exchange. In the early stages, mostly for electricity imports to Nepal, radial power distribution interconnections at various border points (14 points) through MV (33kV) feeders were established with an aggregated distribution capacity of approximately 50MW. In addition, 132kV radial interconnections were commissioned at three points, East (Duhabi), Central (Gandak) and West (Mahendranagar) with an aggregated transmission capacity of 130MW, as is shown in the following exhibit.



(Source: NEA)

Figure 3-15 Power Interconnections between Nepal and India

The construction of a double-circuit 400kV cross-border transmission line with a transmission capacity of 150MW between Dhalkebar (Nepal) and Muzaffarpur (Bihar, India) has just been completed in July 2015. It is expected that the line will be put into commercial operation on 1st November 2015. In addition, several 400kV cross-border transmission options have been specifically discussed with the Indian counterpart, such as Khhalpur – Bareilly (UP), Butwal – Gorakhpur (Bihar) and Duhabi – Purnea (Bihar)

3.3 Possibility of International power trading in Bangladesh

According to the Master Plan 2010, there are six possible connecting points, as indicated by Figure 3-13. Out of these points, that between Baharampur and Bheramara was already connected with HVDC in 2013 as scheduled.
The inter-connection line between Purnia and Bogra will be connected to hydropower in Nepal and that between Alipurduar and Bogra will be connected to hydropower in Bhutan. Both of the lines are connected through substations in India, not directly connected to hydropower stations. Their start of operation will be about 2025.

3.3.1 Short term measures

(1) DC-link
As the existing 500MW HVDC (BTB) has been fully utilized at the maximum level, there is no further possibility of increasing the receiving capacity. There is need to expand the 500MW HVDC as planned and import 500MW electricity through the new HVDC to increase the receiving capacity. Purchasing additional 500MW will possibly drive up the price more than the existing HVDC system; however, it will be possible for Bangladesh to purchase power from the Indian market as well.

(2) Radial inter-connection line
As Figure 3-13 shows, there is an agreement between India and Bangladesh to interconnect from Tripura, India to Comilla, Bangladesh. Bangladesh will receive 100MW power from Tripura, where the 726MW Palatana Gas-fired power plant will be constructed. The method of supplying power is disconnecting partial load in Comilla district from the grid of Bangladesh, then connecting the grid of Tripura and supplying power directly from Tripura.
This inter-connection method is possible anywhere if the grids of both countries are close together. There will be profound effects from alternating electricity demand, especially around the border area where the cities require huge amounts of electricity. Rajshahi is a city with relatively high electricity demand and 100MW of load shifting will be possible in this area. But there is the Padma river, which is at the border of India, and constructing a transmission line over the river is requisite. In addition, as the existing 132kV substation (Lalgola) is 30km from there, it will possibly be economically inefficient due to the huge transmission cost.

3.3.2 Long term measures

As a long term measure, the JICA Survey Team surveyed the development of hydropower potential in the neighboring countries of Bhutan, Nepal, and India, importing power from these neighboring countries to Bangladesh. But transmitting hydropower from these countries to Bangladesh is impossible without the consent of India, which is geographically located between Bangladesh and these countries. In this regards, three new cases of inter-connection have begun to be planned. The details of these three cases are shown in Figure 3-6.
The hydropower potential of each area and the future possibilities for power export to Bangladesh are described as follows.

(1) Hydro power in India
There is abundant hydro power potential in north east India.

(a) Arunachal Pradesh State
A break down of "50,000MW Hydro Electric Initiative" is shown on CEA's website and the potential of hydro power capacity in Arunachal Pradesh State accounts for 42 sites (27,293MW) out of 50,000MW. Though the JICA Survey Team could confirm huge potential, the existing capacity of hydro power stations is at least 463MW as of March 2012 and actual development of hydro power

stations has not yet been making progress. The reason is considered to be that the area is quite far from demand areas and the cost including transmission fees will be economically inefficient. Currently, 800kV HVDC connecting the north-east and central areas is under construction along with a large scale hydro power station. The development of hydro power in this area could be making progress along with the development of transmission lines in the future. It is possible to import power by utilizing the planned Case 2 transmission line (shown in Figure 3-6), but the maximum receiving capacity will be limited to 1,000MW.

(b) Meghalaya State

11 sites totaling 931MW potential of hydro power are described in "50,000MW Hydro Electric Initiative". While the potential of hydro power is not particularly high, the south of Meghalaya State is geographically facing Bangladesh. Accordingly, transmitting power directly to Bangladesh will have more significant advantages in terms of the economic point of view, including transmission cost. Connecting to the grids of both Meghalaya State and Bangladesh, then switching depending on the demand and supply situation, will be considered as one of the connecting methods. Since the JICA Survey Team confirmed the vertical cliff border between Meghalaya State and Bangladesh at the first site survey, high potential of power will be expected if a pumped storage hydro power station can be developed.

(2) Hydro Power in Bhutan

61 sites totaling 14,700MW hydro power (2021-2030 developing plan) potential are reported in "National Transmission Grid Master Plan (NTGMP) for Bhutan" and these potential sites are plotted across the country. As the power needs to be transmitted through India in order to import from Bhutan to Bangladesh, the Case 2 transmission line (shown in Figure 3-6) will be utilized. For this reason, no more than 1000MW capacity of imported power is expected, including Arunachal Pradesh State cases. In this case, the east side terminal of the Case 2 transmission line will possibly be at Rangia substation, which has an advantage because the transmission line distance in east Bhutan will be shorter.

(3) Hydro Power in Nepal

21 sites totaling 12,000MW hydro power potential in the east river side are reported in the long list of Nepal. To import power from Nepal to Bangladesh, power needs to be transmitted through India as well. However, it is impossible to utilize the Case 2 transmission line directly, because its west terminal will be installed in the north or east part of India. For this reason, imported power will be transmitted through existing HVDC after expansion as planned, even though the power from Nepal to Bangladesh will limited to 500MW at the maximum level.

In the case of utilizing the Case 3 transmission line to import power from Nepal as an alternative method, it will be possible to import power by connecting the west terminal of the Case 3 transmission line through the AC/DC converter which will be installed near Barapukuria. In this case, transmission loss will be improved because the power flow will be reverse direction.

(4) Hydro power in Myanmar

There are hydro power potential areas in the mountainous region of western Myanmar. Increasing supply capacity will be expected because Myanmar geographically adjoins Bangladesh and power can be supplied directly from Myanmar. Construction of a transmission line to Chittagong district will be a prerequisite at least in order to transmit power, but economic efficiency, including transmission cost, will deteriorate.

3.3.3 Challenges and Countermeasures of Power Imports

The challenges arising from importing power and their countermeasures are as follows.

(1) Energy Security

In the case of importing power from other countries, the risk of supply interruption caused by adverse relationships between the two countries needs to be considered. Electric power, which is different from other types of supply, is technically easy to shut down even in minutes. So it is necessary to avoid excessive reliance on other countries in order not to place oneself in a serious situation. Specifically, the capacity of imported power from one country should be within the limit of generating reserve margin and also 10% of all supply capacity in order to continue the supply in the event of supply interruption. In the case of Bangladesh, imported power from Bhutan and Nepal has to be transmitted through India. Therefore, imported power from Bhutan and Nepal should be within 10% of all supply capacity.

(2) Massive blackout due to large scale power loss of supply

It is desirable to import as much power as possible through one connecting point from the viewpoint of economic efficiency. However, if a huge amount of power is transmitted through one connecting point, it can lead to the risk of massive blackout, such as blackout across the entire country during the shutdown of the connecting line. Massive blackout occurred on 1st November 2014, triggered by 500MW power loss of the BTB break down on the inter-connection line from India. In order to avoid this risk, the limit of the power loss level needs to be worked out, by checking sufficiently continuous power generators' operation during frequency drop and the load shedding scheme during large scale power supply loss. Based on this result, the maximum level of import capacity in one inter-connection point has to be decided.

(3) Mutual Interference due to Grid Accidents

Conducting power trading means transmission lines are connected between two neighboring countries, which will lead to the threat of mutual interference due to grid accidents. But it is possible to minimize the influence by connecting DC lines. Current inter-connection lines between India and Bangladesh apply DC lines or non-connected lines by switching the load. There will be a few mutual interferences due to grid accidents in these two cases.

Chapter 4 Screening for Hydropower Potential Sites

4.1 Each Country's Hydropower Potential Sites (Long List)

4.1.1 Bhutan

(1) Hydropower Potential

In 2008, Bhutan and India reached an agreement to increase Bhutan's generating capacity by 10,000MW by 2020 through joint projects. The list of 10,000 MW Initiative is shown below. The electric power from these projects is basically aimed to be supplied to India.

Table 4-1 List of 10,000 MW Initiative with Govt. of India

Sl. #	Project	Installed Capacity (MW)	Implementation Mode / JV Partner	Project Cost (Nu. in Million)	Status	Construction Year	Commissioning Year
1	Punatsangchhu-I	1,200	Inter-Governmental (IG)	92,863	Under construction	Nov. 2008	Feb. 2018
2	Punatsangchhu-II	1,020	-do-	74,893	-do-	Dec. 2010	Dec. 2017
3	Mangdechhu	720	-do-	40,695	-do-	Aug. 2010	Sept. 2017
4	Amochhu	540	-do-	37,384	DPR cleared	2014*	2020
5	Sankosh	2,560	-do-	114,720	DPR yet to be cleared	2015*	2022
6	Kuri-Gongri	2,640	-do-	146,800	PFS completed. DPR under preparation	2017*	2026
7	Kholongchhu	600	Joint Venture (JV) / SJVNL	31,436	Under implementation process	2014	2020
8	Bunakha	180	JV / THDC	24,926	DPR cleared	2014*	2020
9	Wangchhu	570	JV / SJVNL	40,028	DPR cleared	2014*	2020
10	Chamkharchhu	770	JV / NHPC	47,760	DPR yet to be cleared	2015*	2024
	Total	10,800					

(Source: DHPS)

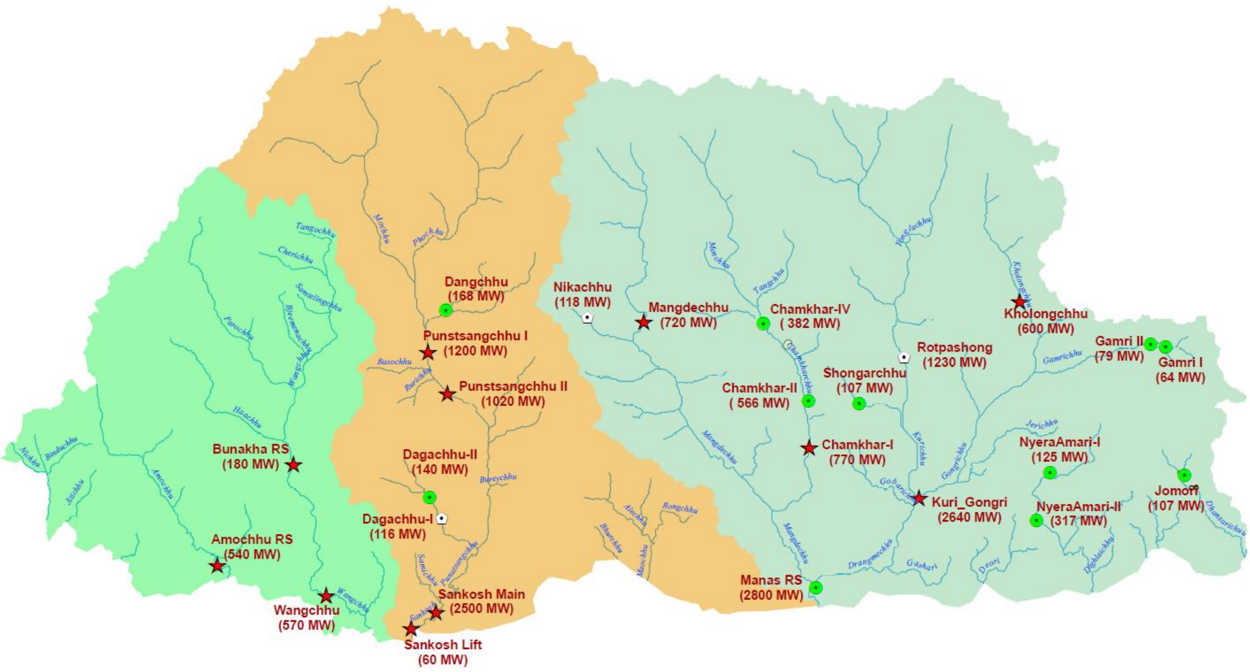
Feasibility studies of a lot of potential sites are being executed besides the above-mentioned project. The list is shown below.

Table 4-2 List of Projects outside 10,000 MW Initiative

	Name of Project	Installed Capacity (MW)	Implementing Agency	Funding Agency	Status
1	Dagachhu	126	DGPC	ADB, NPPF & Tata	Construction completed. Commission in March 2015
2	Nikachhu	118	DGPC	ADB & sourcing other funds	Under construction. To be completed in 2019
3	Kuri-I (Rotpashong)	1,230	DGPC	MoEA, DGPC	DPR under DPR (F/S) and to be completed in the end of 2015
4	Gamri I	45	DGPC	DGPC	Pre-F/S completed in early 2015.
	Gamri II	85			
5	Nyera Amari I	125	DGPC	DGPC	Pre-F/S completed in 2014. To be constructed as "Integrated scheme"
	Nyera Amari II	317			
6	Dangchhu	170	DHPS MoEA	Norwegian Govt.	Pre-F/S to be completed in around February 2015
	Chamkharchhu-II	566			
	Chamkharchhu-IV	382			
7	Shongarchhu	107	DHPS MoEA	Norwegian Govt. thru (ADB)	Shongarchhu: Need for reviewing the project plan due to power house located in protected area.
	Manas	2,600			
	Dagachhu-II	140			

(Source: DoEA)

A location map of these projects is shown below.



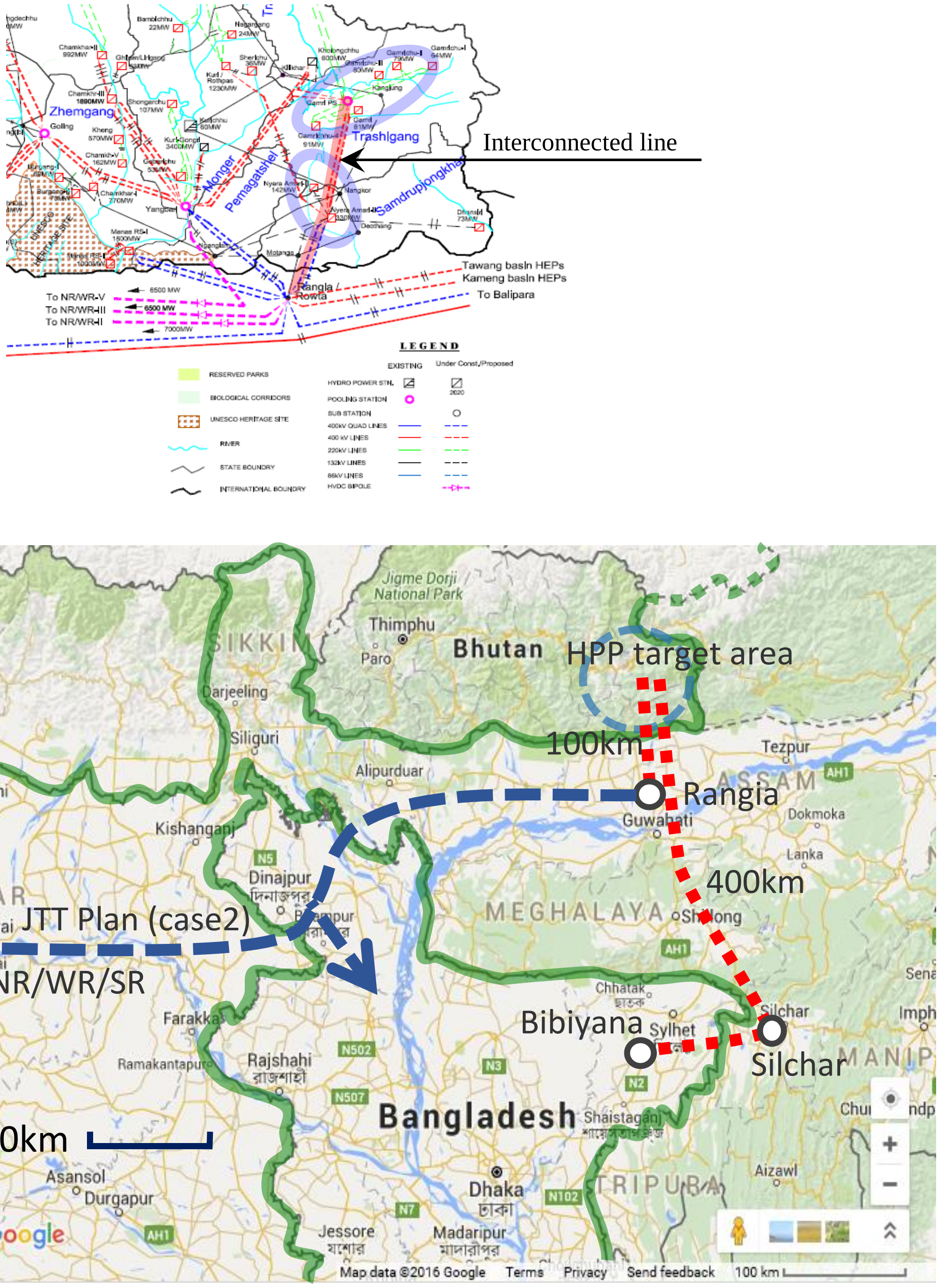
(Source: DHPS)

Figure 4-1 Location of Hydropower Projects

(2) Transmission line route

Based on the meeting with MOEA, it is thought that Nyera Amari site and Gamri site, located in the eastern part of Bhutan, are being prioritized as hydropower development sites in Bhutan. It is preferable to study the route based on the National Transmission Grid Master Plan for Bhutan, though a new transmission line is needed.

If the transmission line is newly established from the Gamri site to Rangia substation (India), it will entail construction work of about 100km. On the other hand, if the transmission line is directly connected to the Bangladesh system, the transmission line will be newly established from the Gamri site to Bibiyana substation through Meghalaya state and Silchar of Assam state, and construction work of about 400km will be needed.



(Source: JICA Survey Team)

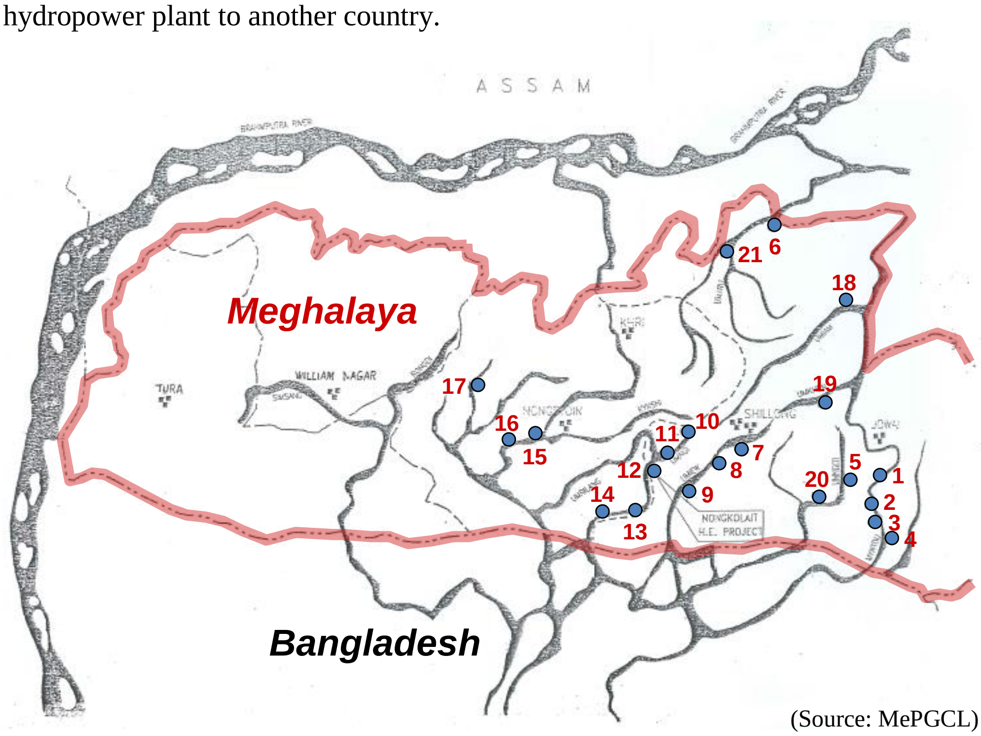
Figure 4-2 Illustration of Transmission Line Route from Bhutan

4.1.2 India (Meghalaya State)

(1) Hydropower Potential

It is said that there is about 3,000MW of hydropower potential in Meghalaya state. The breakdown of "50,000 MW Hydro Electric Initiative" is shown on the CEA website, which states that 11 sites 931MW exist in Meghalaya state.

In the case of selling electricity to Bangladesh, it is necessary to look for sites excluding those where an IPP has already begun investigating, because an IPP is not allowed to sell electric power from a developed hydropower plant to another country.



(Source: MePGCL)

Figure 4-3 Potential Sites in Meghalaya State

Table 4-3 Potential Sites in Meghalaya State

	Project	River Basin	Installed Capacity (MW)	Implementing Agency	Status of Investigation
1	Selim	Myntdu	85	MePGCL	under DPR (to be completed in 2016)
2	Suchen	Myntdu	65	MePGCL	DPR scheduled to be started in 2016
3	Myntdu Leshka Stage-I	Myntdu	3 x 42	MePGCL	Commissioned in 2011-2013
4	Myntdu Leshka Stage-II	Myntdu	280	MePGCL	under DPR (to be completed in March 2016)
5	Umngot	Umngot	210	MePGCL	DPR completed (Originally to be developed by IPP, but likely by MePGCL)
6	New Umtru	Umtru	40	MePGCL	Under construction (to be completed in March 2016)
7	Umjaut	Umiew	69	IPP	to be developed by IPP
8	Umduma	Umiew	57	IPP	to be developed by IPP
9	Mawphu	Umiew	120	NEEPCO	DPR nearly completed
10	Umngi Storage	Umngi	54	MePGCL	DPR not yet planned
11	Rangmaw	Umngi	65	IPP	Not feasible according to IPP
12	Nongkohlait	Umngi	120	MePGCL	under DPR (just started)
13	Nongnam	Umngi	50	IPP	no information
14	Mawpat	Umngi	21	No developer	no information, and no companies interested
15	Kynshi Stage-I	Kynshi	270	IPP	to be developed by IPP
16	Kynshi Stage-II	Kynshi	400	IPP	Cancelled due to economical infeasibility
17	Mawblei	Um Mawblei	140	MePGCL	under DPR (to be completed in 1 year)
18	Umlaphang	Umiam	20	NEEPCO	DPR not yet planned
19	Umkhen	Umkhen	N/A	No developer	no companies interested
20	Umngot Stage-II	Umngot	70	No developer	no companies interested
21	Umiam - Umtru Stage-V	Umtru	25	MePGCL	Located in reserve forest, but MePGCL just started to review

(Source: JICA Survey Team)

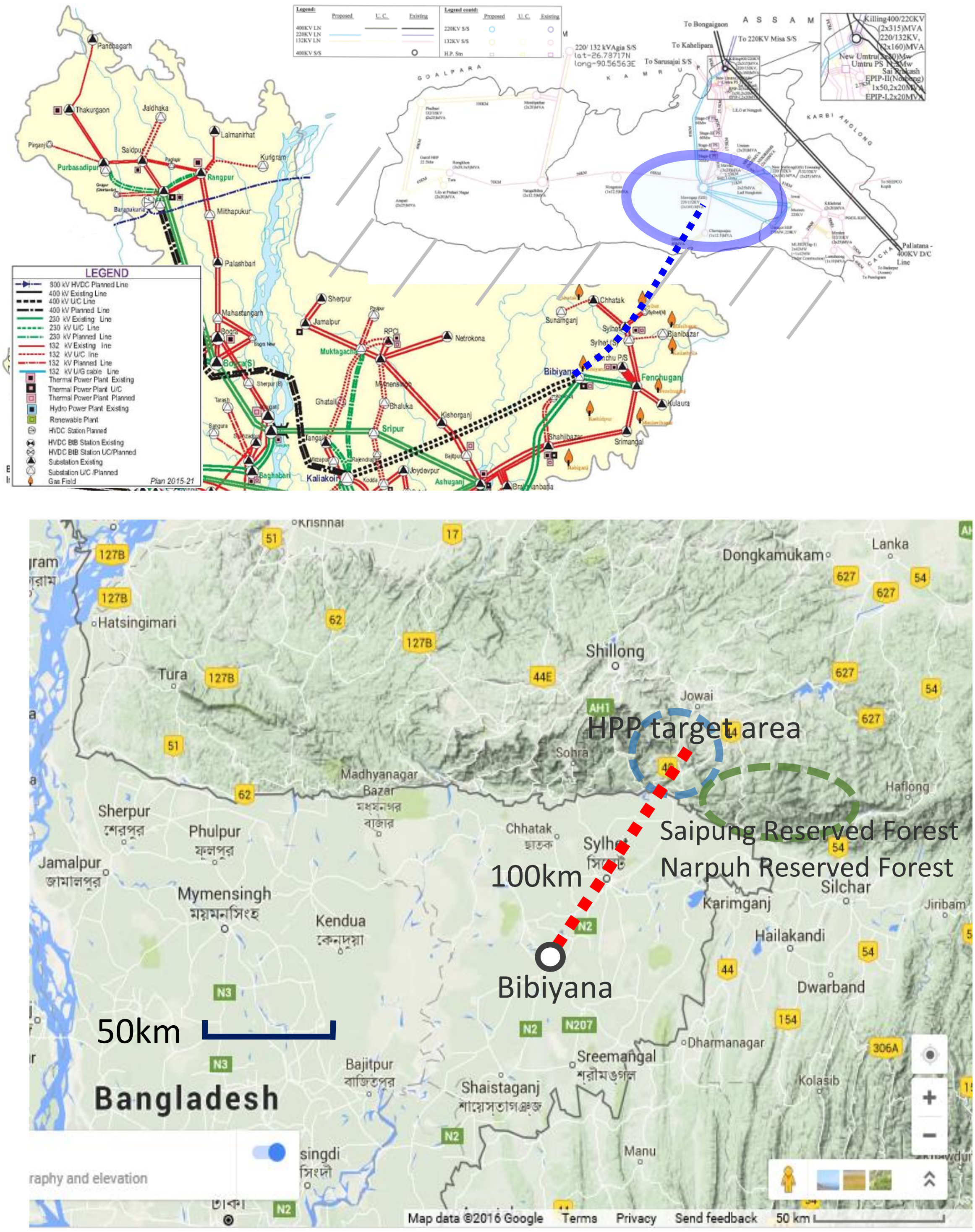
There is a sheer cliff in a region near the border with Bangladesh and Meghalaya state. There are potential sites for pumped storage hydro power plants because the upper reservoir can be adjacent to the lower reservoir with about 1000m differences in elevation.

(2) Transmission line route

A new international interconnection line is needed because there is no interconnection line between Meghalaya state and Bangladesh, though the eastern part of Meghalaya is prioritized as a hydropower development site in Meghalaya state.

Therefore, it is thought that the connection to Bibiyana, where the 400kV substation and 400kV transmission line are under construction, is being prioritized.

If the transmission line is newly established from the hydropower development site in the eastern part of Meghalaya state to the Bibiyana substation, it will entail construction work of about 100km (straight line distance).

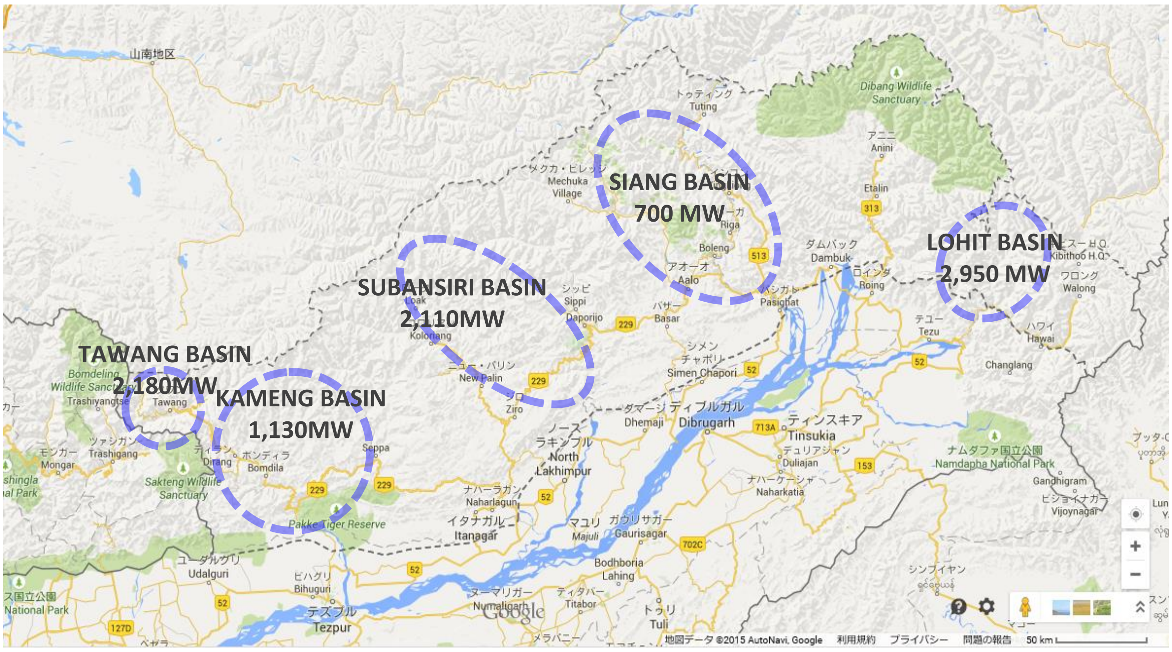


(Source: JICA Survey Team)

Figure 4-4 Illustration of Transmission Line Route from Meghalaya State

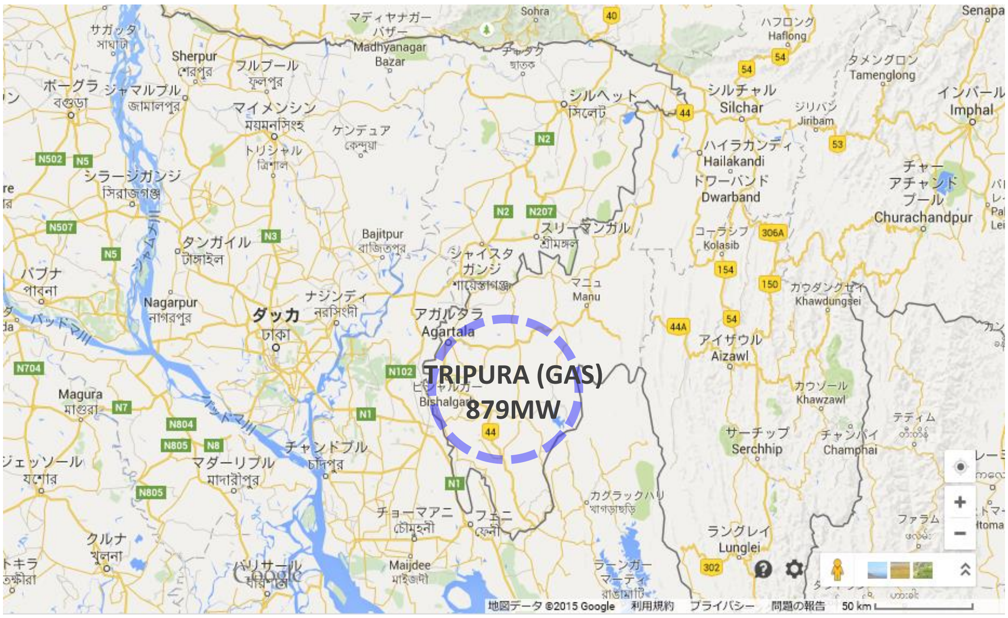
4.1.3 India (Arunachal Pradesh State and Tripura State)

Potential Sites in Arunachal Pradesh State and Tripura State are as follows.



(Source: JICA Survey Team)

Figure 4-5 Potential Sites in Arunachal Pradesh State, India



(Source: JICA Survey Team)

Figure 4-6 Potential Sites in Tripura State, India

Table 4-4 Potential Sites in North Eastern (Arunachal Pradesh, Tripura)

No.	Name of the project	Type of GEN.	Basin	Output (MW)	Owner	Plan
Arunachal Pradesh State						
1	L Subansiri	Hydro	Subansiri	1,000	Central	12 th FYP
2	Kameng	Hydro	Kameng	600	Central	12 th FYP
3	Pare	Hydro	Subansiri	110	Central	12 th FYP
4	L Subansiri	Hydro	Subansiri	1,000	Central	13 th FYP
5	Sew Nafra	Hydro	Kameng	120	IPP	13 th FYP
6	Patel Hydro	Hydro		189	IPP	13 th FYP
7	Adishankar Khuitam	Hydro	Kameng	66	IPP	13 th FYP
8	Ksk Dibbin	Hydro	Kameng	120	IPP	13 th FYP
9	Tawang-I	Hydro	Tawang	600	Central	13 th FYP
10	Tawang-II	Hydro	Tawang	800	Central	13 th FYP
11	Lower Demwe	Hydro	Lohit	1,750	IPP	13 th FYP
12	Kalai-II	Hydro	Lohit	1,200	IPP	13 th FYP
13	Nyamjangchu	Hydro	Tawang	780	IPP	13 th FYP
14	Gmr Londa	Hydro	Kameng	225	IPP	13 th FYP
15	Tato-II	Hydro	Siang	700	IPP	13 th FYP
Tripura State						
1	Monarchak	GAS		101	Central	12 th FYP
2	Palatana U1	GAS		363	Central	12 th FYP
3	Palatana U2	GAS		363	Central	12 th FYP
4	Agartala GAS	GAS		52	Central	12 th FYP

(Source: CEA)

4.1.4 Nepal

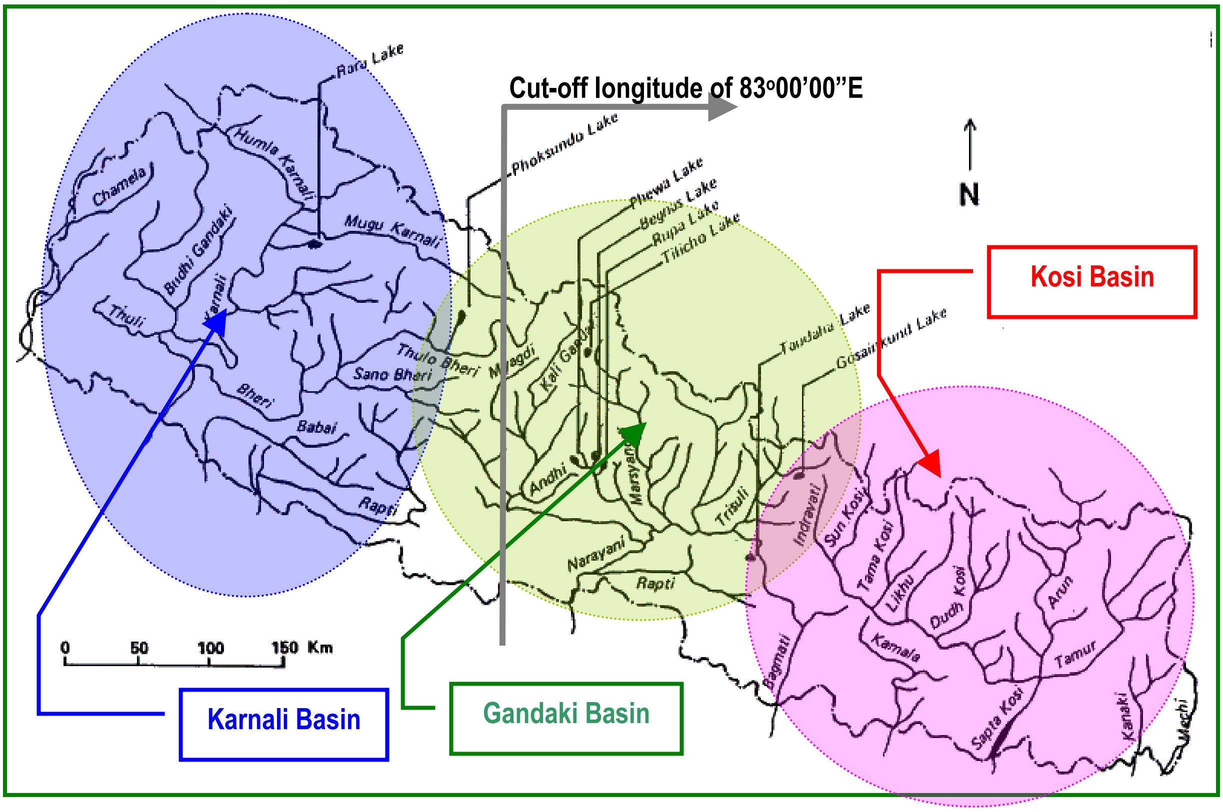
(1) Hydropower Potential

Hydropower potential in Nepal is officially estimated at 83,000MW. There are three major river basins, Koshi, Gandaki, and Karnali, in the country. Despite the huge development potential, the existing hydropower capacity at the end of FY2013/14 is only 787MW (below 1% of the potential) due to prolonged civil war and the lack of an enabling investment framework. However, reflecting an improvement in the relationship with India, a Power Trade Agreement (PTA) was inked by the Governments of Nepal and India. It is envisaged that hydropower development by Build-Own-Transfer (BOT) will be accelerated.

In 2014, a Project Development Agreement (PDA) was signed between the Government of Nepal and respective project developers, GMR (India) for Upper Karnali (900MW) in September and SJVN for Arun-3 (900MW) in December. Nepal is eligible to receive 20% of free energy out of BOT power plants. Thus, BOT development will contribute to boosting the domestic energy supply.

There are a number of hydropower development initiatives in Nepal. Usually, small- and medium-sized projects (below 100MW) tend to sell energy domestically to NEA, whereas larger ones (over 100MW) are export-oriented.

During the 1st Survey, a full list of 151 hydropower projects with survey applications and survey licenses being cancelled was obtained. The size of projects listed varies from mini-hydropower (below 1MW) to gigantic ones (over 10GW). Taking into account power export to Bangladesh, the final long-list includes ones with capacity of over 100MW, located in the Central or Eastern regions of Nepal and with geographical coordinates being east of degrees 83°00'00"E longitude, as is shown in Figure 4-7.



(Source: Food and Agricalture Organization)

Figure 4-7 River Basins in Nepal

The final long-list, consisting of 46 projects, is shown in Table 4-5.

Table 4-5 Long-list for Hydropower Projects for Power Exchange with Bangladesh

SN	Project	Capacity (MW)	River	SN	Project	Capacity (MW)
1	Uttaganaga-Nisi Hydropower Project	300	Uttar Ganga	24	Sunkoshi-C Hydropower Project	500
2	Nisti Panah Storage Project	145	Nisti, Chhaldi, Panangad	25	Tsho Rolpa Pumped Storage	200
3	Andhi Khola Storage Project	150	Andhi Khola	26	Sapta Koshi Storage	3,300
4	Andhi Khola Storage Project	180	Andhi Khola	27	Dudhkosi Khotang HPP	300
5	Kaligandaki Gorge Hydropower Project	111	Kali Gandaki	28	Dudhkoshi-3	150
6	Kaligandaki Storage Hydropower Project	660	Kali Gandaki	29	Dudhkosi-3	450
7	Bhrundi Khola SHP	500	Bhrundi	30	Dudhkoshi - 3	280
8	Seti	128	Seti	31	Dudhkosi-2	250
9	Upper Marsyangdi-1	100	Marsyangdi	32	Dudhkoshi -4	230
10	Dashdhunga	220	Trishuli	33	Dudhkoshi - 2	213
11	Jogimara Trishuli	240	Trishuli	34	Dudhkoshi - 4	197
12	Budhi Gandaki HPP	495	Budhi Gandaki	35	Dudhkoshi - 1	108
13	Budhi Gandaki	600	Budhi Gandaki	36	Dudhkoshi (BASA) Hydropower Project	105
14	Budhi Gandaki-Arket	110	Budhi Gandaki	37	Arun-4 Hydropower Project	303
15	Budhigandaki Hydropower Project	254	Budhi Gandaki	38	Lunsun Pepuwa	300
16	Budhi Gandaki-Uiya	105	Budhi Gandaki	39	Ande Pipal Arun	1,200
17	Budhi Gandaki (Laputhumi)	145	Budhi Gandaki	40	Middle Arun Hydropower Project	204
18	Upper Trishui-2A HPP	229	Trishuli	41	Upper Arun	335
19	Upper Trishuli-2B	102	Trishuli	42	Chokan Lingam	520
20	Sunkoshi-3 HPP	536	Sun Koshi	43	Arun-II	1,300
21	Sunkosi-A Storage HPP	1,350	Sun Koshi	44	Arun-5 Hydropower Project	401
22	Sunkoshi Storage-2 HPP	1,100	Sun Koshi	45	Tamorkhola	500
23	Tamakoshi -1	100	TamaKoshi	46	Tamor Mewa HPP	101

(Source: Ministry of Energy, Department of Electricity Development)

(2) Transmission line route

Between the east region and the northeast region in India, there is a narrow area called the "chicken neck", pinched by Nepal and Bangladesh. For economic activity, all roads, railways, gas pipe lines, and transmission lines have to pass through the "chicken neck".

Therefore, there are many 400kV transmission lines and a ±800kV direct current transmission line (commencement of commercial operation in 2015) in the chicken neck area. The most important issue regarding this interconnected line is to obtain the consent of India, because it is necessary to overpass the existing transmission lines at the "chicken neck area" if a hydropower plant in Nepal directly connects to the Bangladesh system.

Moreover, the construction and maintenance of an interconnected line become difficult because it overpasses very high voltage transmission lines as shown in Figure 4-8.

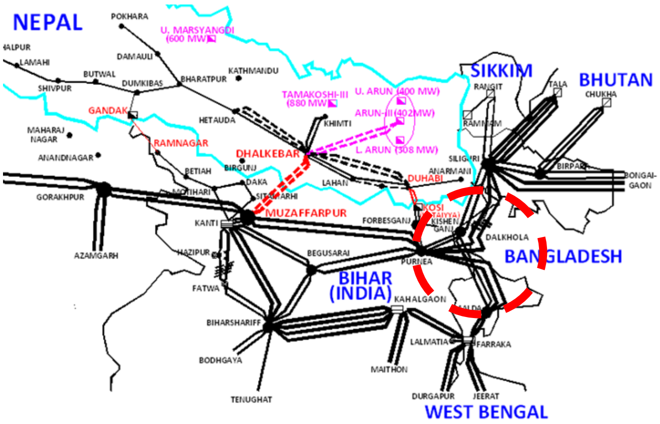


Figure 4-8 Transmission Line Congestion in Chicken Neck Area

In PSMP2010 of Bangladesh, the idea of interconnection with Nepal being connected through a substation in India illustrated in Figure 4-9 was proposed. If a hydropower plant in Nepal directly connects to the Bangladesh system, the distance of the transmission line is about 310-320km (India selects the route so the power line may shorten). This is almost same as the transmission line distance proposed in PSMP2010.

If Case 3 (AC transmission line) in the JTT Report is selected, the power generated in the eastern region of Nepal will be transmitted to Barapukuria BTB in Bangladesh via Purnea substation in India (line length from Nepal to India: 150 km). This option can avoid 400kV transmission line construction in the congested chicken neck area.

The distance between Nepal and Bangladesh in the chicken neck area is about 20km, and interconnection by underground power cable is thought to be one of the choices. It is thought that there is a possibility of considering this as a reasonable solution in the future if there are advantages for India, though it might be impossible to obtain approval from India now.

(Source: JICA Survey Team)

Figure 4-9 Illustration of Transmission Line Route from Nepal

4.1.5 Myanmar

The hydropower potential site map of Myanmar is shown below. The part near the Bangladesh border has been enlarged.

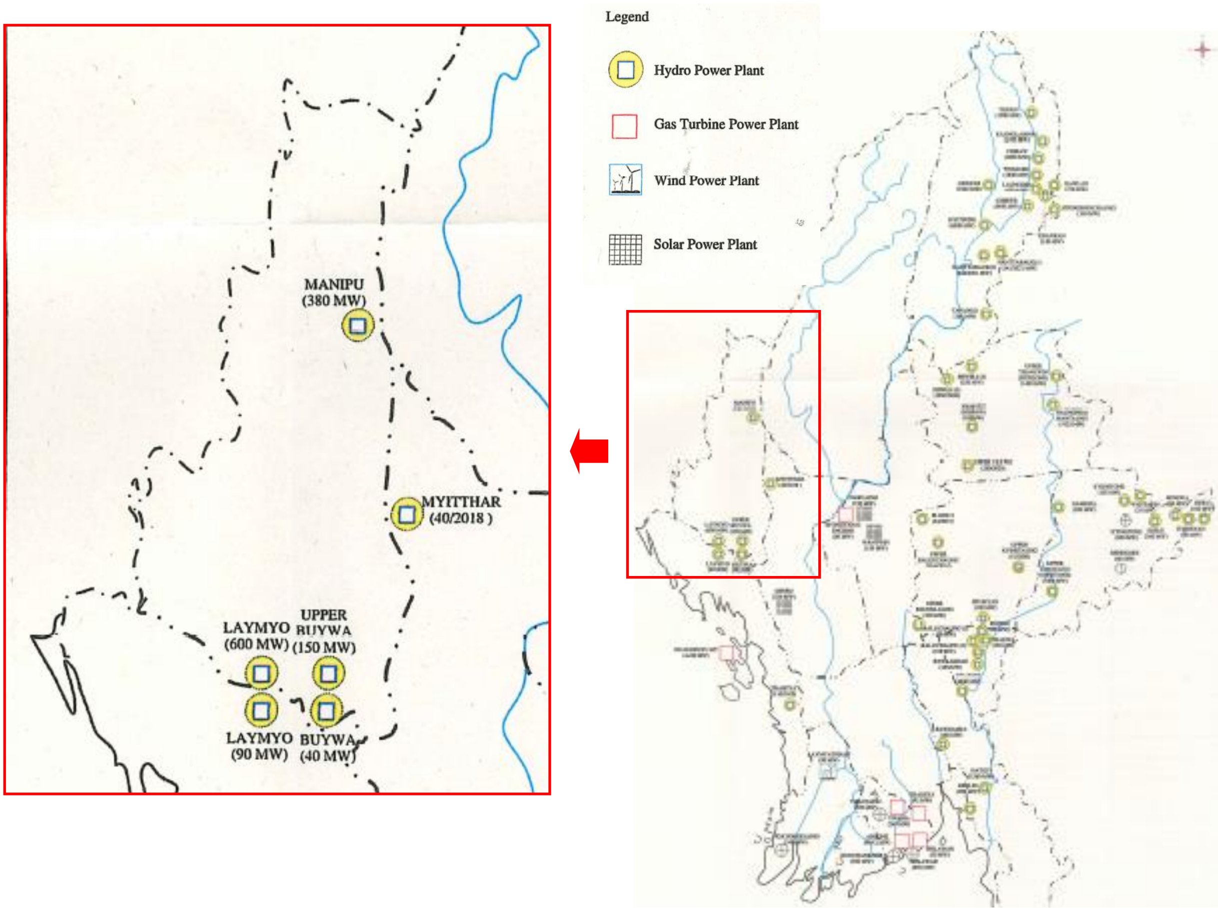


Figure 4-10 Hydropower Potential Site Map of Myanmar

There is potential at five sites 1,260MW according to this map. The current Power Development Plan doesn't include these potential hydropower sites and they will not be developed until 2020.

4.2 Selection of hydropower development candidate area for Bangladesh

4.2.1 Evaluation Criteria Setting

The JICA Survey Team proposes a set of evaluation criteria for the selection of candidate areas for hydropower development for Bangladesh, as is shown in the following table.

Table 4-6 Evaluation Criteria for Candidate Area Selection for Hydropower Development

	Evaluation Items	Evaluation Viewpoint	Importance
1	Political willingness for power trades with Bangladesh	Including hydropower development policy and institutional supporting measures	High
2	Demand-Supply Balance in hydropower development host country	The more surplus energy (even during the dry season) the host country secures, the more points earned. (with more opportunity to receive energy for Bangladesh)	Medium
3	Hydropower development potential volume	The more potential there is, the more opportunity to identify economically viable sites. Thus, higher score earned.	Medium
4	Interconnection modality with Bangladesh	Direct connection to Bangladesh is preferable over indirect connections through other network systems.	Medium
5	Proximity to the connection point in Bangladesh	The closer the better. This criterion includes ease of transmission line construction.	High
6	The value of electricity at the receiving point in Bangladesh	Connection to an area where there are fewer power sources is favored.	Low

(Source: JICA Survey Team)

All these evaluation items are of great importance in selecting candidate areas for hydropower development for Bangladesh. However, "political willingness for power trades with Bangladesh" and "proximity to the connection point in Bangladesh" are considered to be the most important.

4.2.2 Possible Candidate Areas for Hydropower Development to be connected with Bangladesh

(1) Possible Areas for Interconnection

The JICA Survey Team considers the following six areas to be possible candidate areas for hydropower development to be connected with Bangladesh.

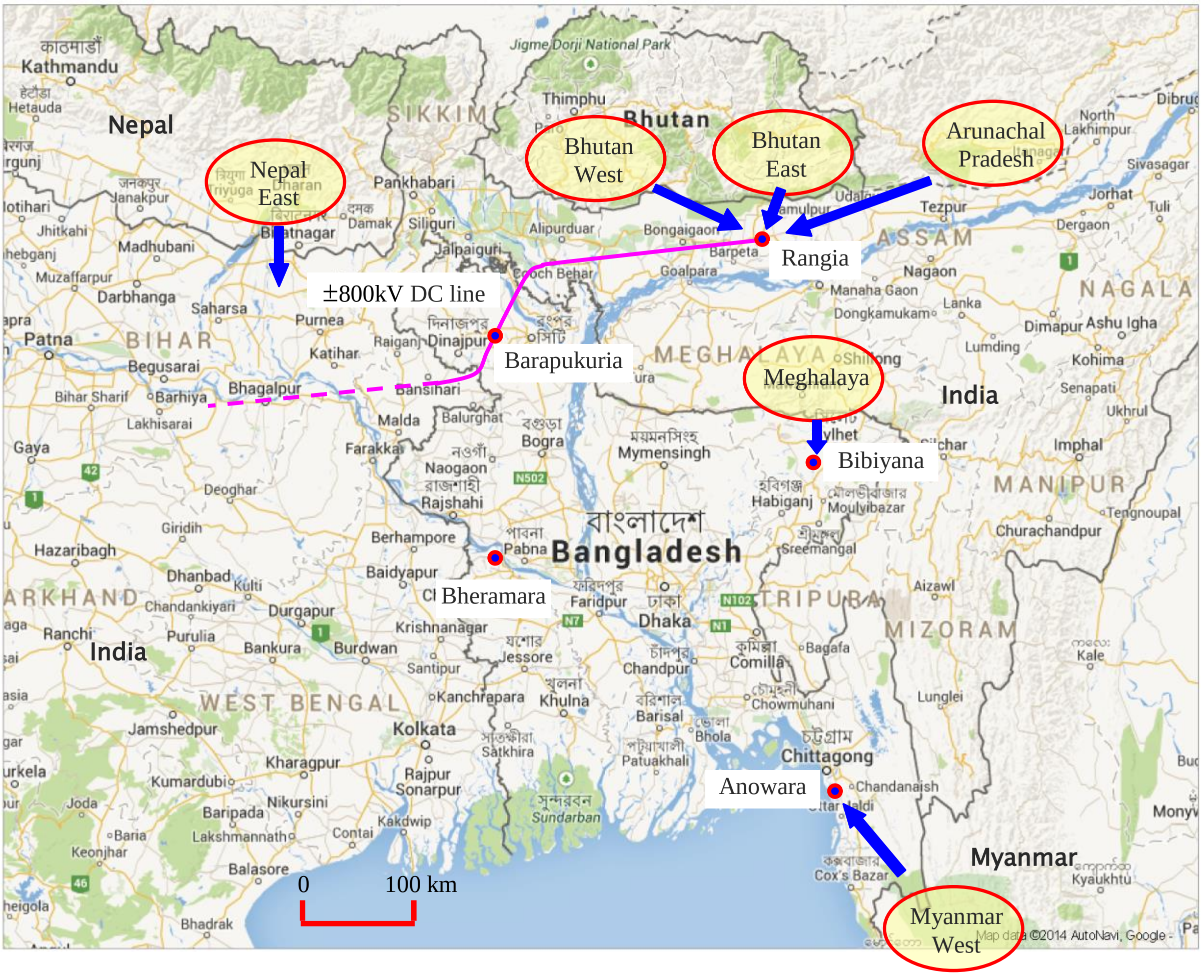
Table 4-7 Candidate Areas for Hydropower Development to be Connected with the Bangladesh System

	Hydropower Development Area	Connecting point in Bangladesh	Connection Modality
1	Eastern Nepal	West (Bheramara)	To transmit energy to the closest substation in India and to connect the existing BTB in West Bangladesh through the Indian domestic network.
2	Western Bhutan	North (Barapukuria)	To transmit energy to Rangia S/S in India and to connect with the Bangladesh grid in North Bangladesh through ±800kV HVDC link.
3	Eastern Bhutan	North (Barapukuria)	To transmit energy to Rangia S/S in India and to connect with the Bangladesh grid in North Bangladesh through ±800kV HVDC link.
4	Meghalaya State, India	East (Bibiyana)	To directly connect with Bibiyana S/S
5	Arunachal Pradesh State, India	North (Barapukuria)	To transmit energy to Rangia S/S in India and to connect with the Bangladesh grid in North Bangladesh through ±800kV HVDC link.
6	Western Myanmar	South (Anowara)	To directly connect with Anowara S/S

(Source: JICA Survey Team)

(2) Connection Illustration of Potential Hydropower Development Areas

The following map shows an illustration of the connection of hydropower development areas with Bangladesh.



(Source: JICA Survey Team)

Figure 4-11 Connection Illustration of Hydropower Development Areas with Bangladesh

4.2.3 Screening Based on the Evaluation Criteria

(1) Political Willingness for Power Trades with Bangladesh

In all the areas except Myanmar, the Governments are very much willing to undertake power trading with Bangladesh. It should be noted that the Government of Bhutan has the intention to prioritize hydropower development in the eastern area over the western area, where hydropower development is rather active, in order to seek balanced economic development in the country.

(2) Demand-Supply Balance in hydropower development host country

Nepal currently faces severe power shortages due to its lack of supply capacity, exercising rotational load shedding routinely. It is expected that large hydropower plants will start operating in the near future, improving the demand-supply situation in the wet season. However, as this will not solve the demand-supply balance in the dry season, the securing of an energy surplus to sell to the rest of the region would not be envisaged. On the other hand, both in Bhutan and the State of Arunachal Pradesh, where there is enough supply capacity, it is possible to sell their surplus capacities to the rest of the region. In the State of Meghalaya, where it sells wet season surplus to other states and purchases power back in the dry season on a regular basis, surplus capacity in the dry season cannot be expected.

(3) Hydropower development potential volume

There is huge hydropower development potential in all the areas except for the State of Meghalaya. However, from the viewpoint of pumped-storage, there is prospective potential in Meghalaya.

(4) Interconnection modality with Bangladesh

It is possible to connect with the Bangladesh power system directly from the State of Meghalaya and Myanmar. On the other hand, transmitting energy through the Indian grid is prerequisite when Bangladesh receives power from Nepal or Bhutan. In the case that Bangladesh imports hydro energy from Bhutan or Arunachal Pradesh, Bangladesh can tap energy at the northern receiving point though a proposed ±800kV HVDC link between Northeast and Central India via Bangladesh. When Bangladesh purchases energy from Nepal, it would receive it at Bheramara BTB, where capacity augmentation is envisaged, passing a long way through Indian domestic power transmission network.

(5) Proximity to the connection point in Bangladesh

If hydropower in the State of Meghalaya is connected directly to Bibiyana S/S in Bangladesh, only 50km of transmission I lines are required. In the case of smaller capacity, such as 132kV transmission, the distance to the nearest substation may be approximately 20 to 30km. In transmitting hydro energy from Bhutan or Arunachal Pradesh, it will be prerequisite to be connected to Rangia S/S where an eastern AC/DC conversion station is located for the proposed ±800kV HVDC link between Northeast and Central India via Bangladesh. Because eastern Bhutan is close to Rangia S/S, transmission distance is within 100km. However, in evacuating hydro energy from western Bhutan, the transmission distance may exceed 200km. Also, receiving hydro energy from Arunachal Pradesh may require transmission lines over 200km. In the case of receiving hydro energy from Nepal, connection to the nearest substations in India allows Bangladesh to use the Indian domestic power networks. Therefore, transmission distance is considered to be less than 100km. Connection of hydro energy from Myanmar may require a transmission distance of over 200km.

(6) The value of electricity at the receiving point in Bangladesh

Connection to the load center may be the most valuable. However, each of the hydropower potential target areas in question is distant from the load center in Bangladesh. The next favorable case is connection to areas with supply capacity deficit. Because power plants are concentrated to the east of the Jamuna River, any supply capacity west of the Jamuna River will be highly appreciated. The currently proposed power receiving point along the proposed ±800kV HVDC link between Northeast and Central India is located at Barapukuria, east of the Jamuna River. Therefore, the value of electric power with this link is considered to be a little bit higher than that of electricity to be received east of the Jamuna River from the Indian State of Meghalaya or Myanmar. The value of hydro energy from Myanmar in particular may be relatively lower at the power receiving point because thermal power development at a larger scale is envisaged in southern Bangladesh.

(7) General Evaluation

The results of the screening mentioned above are summarized in the following table.

Table 4-8 Screening Results

		Weight	Nepal	Bhutan		India		Myanmar
			East	West	East	Meghalaya	Arunachal	West
1	Political will for electricity export	3	5	3	5	5	5	2
2	Demand & supply balance	2	2	5	5	4	5	2
3	Hydro power potential	2	5	5	5	3	5	4
4	Connection method	2	3	2	2	5	2	5
5	Distance to connecting point	3	4	2	4	5	2	2
6	Value of electricity at connecting point	1	4	4	4	3	4	2
	Total		51	43	55	57	49	36

(Source: JICA Survey Team)

As a result of the above comparison, it is considered that hydropower development in the Indian State of Meghalaya and Bhutan is relatively promising. As for Nepal, when its supply-demand situation improves, the area would become promising.

With regard to Myanmar, without having an opportunity to visit, the JICA Survey Team can hardly confirm detailed information such as the Government's willingness to undertake power trading with Bangladesh. However, depending on the results of the confirmation on local situations, Myanmar may become a good candidate area for hydropower development for Bangladesh.