KINGDOM OF BHUTAN
DEPARTMENT OF ENERGY
MINISTRY OF ECONOMIC AFFAIRS

THE PREPARATORY SURVEY

ON

RURAL ELECTRIFICATION PROJECT (PHASE-2)

IN

KINGDOM OF BHUTAN

FINAL REPORT

November 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
EXEIDEA LTD.

Exchange rate used in the report (Nov. 2010)
USD 1 = JPY 87.7
USD 1 = BTN 46.6
BNT 1 = JPY 1.88

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Abbreviations	English
	Bhutan Agencies
BBSC	Bhutan Broadcasting Service Corporation
BEA	Bhutan Electricity Authority
BHU	Basic Health Unit
BPC	Bhutan Power Corporation
BTL	Bhutan Telecom Ltd.
CA	Competent Authority
CHPCL	Chukha Hydro Power Corporation Ltd. (former: Chukha Hydro Power Corporation: CHPC)
DCS	Distribution Construction Section
DFO	District Forestry Office
DHR	Department of Human Resources, under Ministry of Labor and Human Resources
DOA	Department of Agriculture
DOE	Department of Energy (former: Department of Power)
DOF	Department of Forest (former: Department of Forestry Services)
DOP	former: Department of Power (now: Department of Energy)
DoSLR	Department of Survey and Land Records
DOR	Department of Roads
DYT	Dzongkhag Yargay Tshogdu / Dzongkhag Development Committee
GYT	Gewog Yargay Tshogdu / Gewog Development Committee
HSD	Hydromet Services Division
MTI	Ministry of Trade and Industry
MHA	former: Ministry of Home Affairs (now: Ministry of Home and Cultural Affairs)
MoWHS, MWHS	Ministry of Works and Human Settlement
MOA	Ministry of Agriculture
MOF	Ministry of Finance
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
RCSC	Royal Civil Service Commission
RED（DOE), DOE/RED	Renewable Energy Division
RED（BPC), BPC/RED	Rural Electrification Department
RGoB	Royal Government of Bhutan
RNR-RC	Renewable Natural Resources Research Centre
	Foreign organizations
ACB	Austrian Coordinate Bureau
ADB	Asian Development Bank
ADF	Asian Development Fund
ANSI	American National Standards Institute
DANIDA	Danish Development Assistance (under the Royal Danish Ministry of Foreign Affairs)
e7	An international NGO consisted of major 9 electric power companies from the seven G7 member countries
EOJ	Embassy of Japan
GEF	Global Environment Facility
Helvetas	NGO based in Switzerland

List of Terms

Abbreviations	English
IDA	International Development Association
IEC	International Electrotechnical Commission
IMF	International Monetary Fund
IUCN	International Union for Conservation of Nature and Natural Resources
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency (Japan)
NORAD	Norwegian Agency for Development Cooperation
PTC	Power Trading Corporation of India Ltd.
SDA	Sustainable Development Agreement, Netherlands
SDS	Sustainable Development Secretariat, Netherlands
SNV	Stichting Nederlandse Vrijwilligers; NPO established in Netherlands
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WB	World Bank
WWF	World Wildlife Fund
	Unit/Technical Terms
AAAC	All-Aluminum Alloy Conductor
AAC	All-Aluminum Conductor
ABC	Aerial Bundle Cable
ACSR	Aluminum Conductor Steel Reinforced
ASTER	Advanced Spaceborne Thermal Emission and Reflection radiometer
AVR	Automatic Voltage Regulator
BS	British Standards
B-C, B/C	B: Benefit, C: Cost
CFL	Compact Fluorescent Lamp
Ch	Chetrum
EIRR, FIRR	Economic/Financial Internal Rate of Return
EL.( ) m	Meters above Sea level
FY	Fiscal Year
GIS	Geographic Information System
GDP	Gross Domestic Product
GHG	Green House Gas
GWh	Giga Watt Hour (one billion watt hour)
HV	High Voltage
IRR	Internal Rates of Return
kW	kilo Watt
LED	Light Emitting Diode
LV	Low Voltage
MIS	Management Information System
MV	Middle Voltage
MW	Mega Watt (one million watt)
Nu.	Ngultrum; Bhutanese currency; 1 Nu. ≈ ¥2.6 US$1=45 Nu., if not specified
OPGW	Optical-Fiber Composite Overhead Ground Wire
Paise	Paisa (singular); Indian currency; Rs 1 = 100 paisa
PLC	Power Line Carrier
PV	Photovoltaic
SHS	Solar Home System

List of Terms

Abbreviations	English
SHLS	Solar Home Lighting System
SHWS	Solar Hot Water System
SWER	Single Wire Earth Return
TOE	tonne of oil equivalent
USc	US Cent; $1 = 100 c
US$	US Dollar
	Others
ARE	Accelerated Rural Electrification
BC	Biological Corridor
BLSS	Bhutan Living. Standard Survey
CDM	Clean Development Mechanism
Chimi	Member of Congress
DFO	Dzongkhag Forest Office
C/P	Counterpart
Dungkhag	Sub-district
Dungkhag Administration	Sub-district administration
Dungpa	Sub-district administrator
Dzongkhag	District
Dzongda	Governor of the district
Dzongkhag Administration	District administration
Dzongrab	Vice Governor of the district
EC	Environmental Clearance
EIA	Environment Impact Assessment
EMP	Environmental Management Plan
FYP	Five Year Plan
F/S	Feasibility Study
Gewog	Block
GNH	Gross National Happiness
Gup or Mandal	Executive Officer of Gewog
HEPP	Hydroelectric Power Project
ICB	International Competitive Bidding
IEE	Initial Environmental Examination
JBIC SAPROF Study	JBIC Special Assistance for Project Formation Study
JPST	JICA Preparatory Survey Team
IEMMP	Integrated Energy Management Master Plan
Kamzhing	Dry land
LCB	Local Competitive Bidding
L/A	Loan Agreement
Mangmi	Elected Representative of Gewog
MOU	Memorandum of Understanding
M/M	Minutes of Meeting
M/P	Master Plan
NGOs	Non Governmental Organizations
NOC	No Objection Certificate
ODA	Official Development Assistance
O&M	Operation and Maintenance
PA	Protected Area
PSMP	Power System Master Plan
RE	Rural Electrification
REC	Rural Electrification Center
REMP	Rural Electrification Master Plan
RESCO	Rural Electrification Service company

List of Terms

Abbreviations	English
ADB PPTA	Project Preparatory Technical Assistance by ADB
ADB/RE-1	Rural Electrification Programme Phase I funded by ADB
ADB/RE-2	Rural Electrification Programme Phase II funded by ADB
ADB/RE-3	Rural Electrification Programme Phase III funded by ADB
ADB/RE-4	Rural Electrification Programme Phase IV funded by ADB
ADB/RE-5	Rural Electrification Programme Phase V funded by ADB
SEA	Strategic Environmental Assessment
S/W	Scope of Works
TOR	Terms of Reference
T/A	Technical Assistance
Tshogpa	Member of the village council
VEC	Village Electrification Committee

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SUMMARY

AND

RECOMMENDATIONS

SUMMARY AND RECOMMENDATIONS

Project Scope

The quantity and cost of material procured in the project is summarized by dzongkhags in Table-S.1 and Table-S.2. Within these dzongkhags, there were 71 feeder lines which extend 566 km of MV lines and 447 km of LV lines (as shown in Table-S.1). The total Project cost is estimated to be JPY 2,713 million (USD 30.9 million) out of which JPY 1,867 million (USD 21.3 million) is required for the procurement of materials and construction as the base-cost for JICA financing shown in Table S.3. There are compensation costs and environmental monitoring costs of BTN 40 million (USD 0.9 million) and BTN 5 million (USD 0.1 million) respectively, which are described in Chapter 8 more in detail. The consultancy is expected to continue in the similar setup as adopted in JICA RE-1 with the cost estimate of JPY 43.4 million (USD 0.5 million).

Also, BTN 119 million (USD 2.5 million) is allocated to Bhutan Power Corporation (BPC) for execution and supervision of electrification projects as administration.

Table S.1 Project Quantity Summary

Dzongkhag	Nos. of Total consumer (household and institute)	MV length (km)	LV length (km)	Nos. of substation	Nos. of ARCB	Lightning damage prevention		Average headloading distance to village (km)
						Shield wire (km)	Nos. of Couter-poise	
Chukha	629	121.1	68.4	59	33	290	700	13.2
Dagana	416	77.2	61.8	35				6.8
Haa	99	28.6	8.4	11				30.3
Paro	43	7.1	1.5	2				4.0
Pemagatshel	168	21.0	17.2	11				12.2
Punakha	49	10.5	6.1	5				2.2
Samtse	988	100.0	121.8	82				8.3
Sarpang	730	119.0	99.3	65				26.6
Trongsa	321	35.7	28.6	22				4.1
Tsirang	93	20.6	22.9	9				6.3
Wangdue	165	25.3	11.4	16				6.5
Total	**3,701**	**566.0**	**447.4**	**317**	**33**	**290**	**700**	

(Prepared by JPST)

Table S.2 Project Cost Summary

		Material cost (Million JPY)	Erection cost (Million JPY)	Headloading cost (Million JPY)	Transportation cost (Million JPY)	Total cost (Million JPY)	Total cost (Million USD)
Distribution lines	Chukha	204.7	29.1	75.7	3.2	312.9	3.6
	Dagana	152.2	19.7	29.2	3.0	204.1	2.3
	Haa	39.7	6.5	33.2	1.7	81.0	0.9
	Paro	9.7	1.3	1.1	0.3	12.4	0.1
	Pemagatshel	39.2	5.5	13.5	0.7	59.0	0.7
	Punakha	16.5	2.1	1.2	0.8	20.6	0.2
	Samtse	245.2	32.1	56.1	2.4	335.8	3.8
	Sarpang	244.1	37.7	174.9	6.7	463.4	5.3
	Trongsa	72.5	9.2	8.7	2.4	92.8	1.1
	Tsirang	42.7	5.6	7.6	0.8	56.6	0.6
	Wangdue	49.4	6.2	8.7	2.4	66.6	0.8
Other items	ARCB	89.2		29.4	3.6	122.2	1.4
	Shield wire	23.7		7.8	0.9	32.5	0.4
	Counter-poise	5.2		1.7	0.2	7.1	0.1
	Total	**1,233.9**	**193.9**	**410.0**	**29.1**	**1,867.0**	**21.3**

Table S.3 Project Cost*

Annual Fund Requirement

Base Year for Cost Estimation:	Nov, 2010		
Exchange Rates	Nu = Yen		1.88
Price Escalation:	FC:	1.8%	LC: 2.4%
Physical Contingency	10%		
Physical Contingency for Consultant	10%		

	Item	Total				
		FC (Million JPY)	LC (Million BTN)	Total (Million JPY)	Total (Million USD)	Percentage to grand total
A. ELIGIBLE PORTION						
Ⅰ)	Procurement / Construction	1,348	395	2,091	23.8	76.2%
	1. Substation and Line Materials	1,212	12	1,234	14.1	45.0%
	2. Transportation Cost	0	15	29	0.3	1.1%
	3. Erection Cost	0	321	604	6.9	22.0%
	Base cost for JICA financing	1,212	348	1,867	21.3	68.0%
	Price escalation	13	11	34	0.4	1.2%
	Physical contingency	123	36	190	2.2	6.9%
Ⅱ)	Consulting services	38	3	43	0.5	1.6%
	Base cost	34	2	38	0.4	1.4%
	Price escalation	1	0	1	0.01	0.0%
	Physical contingency	3	0	4	0.05	0.1%
Total (Ⅰ + Ⅱ)		1,386	398	2,134	24.3	77.8%
B. NON ELIGIBLE PORTION						
a	Procurement / Construction	0	51	97	1.1	3.5%
	5. Compensation including the removal of orchard trees	0	40	76	0.9	2.8%
	6. Envirenmental Monitoring	0	5	10	0.1	0.4%
	Base cost for RGoB financing	0	46	86	1.0	3.1%
	Price escalation	0	1	2	0.02	0.1%
	Physical contingency	0	5	9	0.1	0.3%
b	Land Acquisition	0	0	0	0.0	0.0%
	Base cost	0	0	0	0.0	0.0%
	Price escalation	0	0	0	0.0	0.0%
	Physical contingency	0	0	0	0.0	0.0%
c	Administration cost	0	119	223	2.5	8.1%
d	BIT (local)	0	8	15	0.2	0.5%
e	BIT (foreign)	0	1	1	0.01	0.0%
f	Duties and Sales Tax	0	129	242	2.8	8.8%
Total (a+b+c+d+e+f)		0	308	578	6.6	21.1%
TOTAL (A+B)		1,386	706	2,713	30.9	98.9%
C. Interest during Construction		25	0	25	0.3	0.9%
	Interest during Construction(Const.)	25	0	25	0.3	0.9%
	Interest during Construction (Consul.)	0	0	0	0.0	0.0%
D. Commitment Charge		6	0	6	0.1	0.2%
GRAND TOTAL (A+B+C+D)		1,417	706	2,744	31.3	100.0%
E. JICA finance portion incl. IDC (A + C + D)		1,417	398	2,166	24.7	78.9%

Note Administration cost =10%

Prepared by JPST)

Cost Evaluation

The average of investment for the project is JPY 460,688 (USD 5,253) per customer.

Grid Specification

It has been agreed that the JICA Preparatory Survey Team (JPST) will follow the design specifications that have been agreed upon between BPC and Project Preparatory Technical Assistance (PPTA) of Asian Development Bank (ADB). Although the project packages for the next phase is the continuation of the on-going rural electrification, there is one major change to be introduced. The tubular pole for conductor line support is to be replaced by telescopic poles.

Improvement of Power Supply Reliability

Based on the analysis of fault records of BPC, JPST recommends introducing a program aiming at the reduction of lightning damages and loss by the installation of overhead shield wire and counter-poise. JPST also recommends installing counterpoise to the existing transformer poles to lower the grounding resistance. These measures need to be introduced in all the southern dzongkhags (district) where lightning damages are frequent. Another feature for the improvement of reliability is the introduction of auto-reclosers, ie. automatic reclosing circuit breaker with a function to restore circuit.

Environmental and Social Considerations

In Sarpang and Wangduephodrang dzongkhags, the proposed distribution lines are located in Jigme Singye Wangchuck National Park or biological corridors. 34.2 km for Sarpang is located inside the protected area or biological corridor. 17.3km for Wangduephodrang is located inside the protected area. For these areas, the covered conductors with narrower arm span will be used with routes taken mostly on existing roads so as to minimize tree cutting needs and disturbance to animal habitats.

Electrification will bring many positive socio-economic impacts and households will have the opportunity to increase their incomes. Moreover, there will be tangible benefits to women by free them from chores with the use of electric appliance for more productive work. Electricity will reduce the consumption of firewood, thereby positively contributing to the protection of environment as well as public health. The provision of electricity will reduce indoor smoke pollution and will improve health condition of village people through reducing respiratory and eye ailments, which are more common to women, children and the elderly.

There will be no involuntary resettlement needs or land acquisition for the Project. There may be some compensation needs for the removal of orange and other orchard trees to clear the right-of-way for the conductor lines. The compensation cost is estimated to be BTN 40 million and the environmental monitoring cost at BTN 5 million.

Implementation Method

The implementation of rural electrification by BPC is vertically divided into three components, of procurement, transport, and civil work, instead of commissioning the entire work to a single or multiple contractors as a package.

Implementation Schedule

The time of completion of the Project is targeted at the end of June 2013. Accordingly, the entire implementation period would only be 29 months since the Project is supposed to commence in February 2011. In order to realize this target for time for completion on schedule, an implementation schedule based on the past experience and the consensus between BPC and

JPST is recommended as shown below.

TableS.4 Implementation Schedule

	Month
	0
Pledge	0
Signing of Loan Agreement	0
	0
Pre Construction Stage	
Implementing Consultant	11
Prepareation of Bid Document	1
Concurrence by JICA	1
Tender Floating	2
Bid Evaluation	1
Approval by CTC and Board Committee	1
Concurrence by JICA	1
Contract procedure with Consultant	1
Procurement of Materials (ICB)	18
Preparation of BOQ	2
Preperation of Bid Document	1
Concurrence by JICA	1
Tender Floating	1.5
Bid Evaluation	1.5
Approval by CTC and Board Committee	1
Concurrence by JICA	1
Contract with Suppliers	1
Civil and Installation Work (LCB)	
Preperation of Bid Document	2
Concurrence by JICA	1
Tender Floating	1.5
Bid Evaluation	1.5
Approval by CTC and Board Committee	1
Contract with Suppliers	1
Construction Stage	
Design and Type Tests on Telescopic Poles	2
Manufacturing of Telescop Poles and Delivery to P'lin	8
Manufacturing of Other Materials and Delivery to P'lin	9
Inland Transportation from P'lin to MicroStories	3
Civil and Installation Work	14
Commissioning	10

For timely implementation, BPC may start the preparation of the material procurement package tender as early as this year.

Implementation Organization

The project will constitute the last portion of rural electrification. Since the main implementation body of Rural Electrification Department has expanded from 44 to 160 according to the SAPROF report for JICA RE-1, the implementation organization of the on-going rural electrification should be maintained and continue with the division of work as follows;

Table S.5 Implementation Organization

Process	Organization in Charge
Material Procurement	Procurement Department
Inventory Control and Transport	Procurement Department
Construction Supervision	Rural Electrification Department
Operation and Maintenance	Electricity Service Division

Capacity Development

BPC need to further improve its implementation capacity in planning, supervision and operation. The first challenge is meeting the national goal of "Electricity for All by 2013." Given the limited timeframe, the procurement lot size has to be minimized and work flow needs to be synchronized. Accurate information sharing is also crucial in eliminating waste and lost time. In order to meet these goals, four areas for capacity development are recommended;

1) Capacity Development in Management Information System (MIS)
    - ✓ Strategic MIS development: development of overall management information handling system as well as conventional infrastructure.
    - ✓ Integration of Geological Information System (GIS) with other MIS application and database.
2) Construction Supervision and Inventory Control: Getting on with Just-in-Time
    - ✓ Training in Just in Time to prepare the planners in procurement and inventory control to streamline the process and minimize the delivery time for the target national goal of "Electricity for All by 2013."
    - ✓ Civil contractors education for proper costing and logistic planning
3) Capacity Development in Power Supply Operation
    - ✓ Strengthening of National Load Dispatch Center

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CHAPTER 1 INTRODUCTION

1.1 Background

Bhutan has a net surplus of electricity as the installed generation capacity is more than the total domestic demand. Presently, only about 65% of Bhutan's population has access to electricity. About 70% of the total population lives in rural areas and only about 50% of the total rural households have access to electrical lighting. Accordingly, the Royal Government of Bhutan (RGoB) is highly committed to develop and promote rural electrification (RE) projects, which are expected to bring immense socio-economic benefits and improve the living conditions of the rural people.

During the 10th Five Year Plan (10FYP) starting from 2008 until 2013, poverty alleviation has been included as a core theme in the development process. Moreover, making electricity accessible to the rural population through RE programs has been identified as one of the conduits for reducing poverty. Accordingly, the RGoB has targeted providing 'Electricity for all' by 2013. Coverage is expected to reach 84% of the population by 2012 with the completion of two ongoing projects supported by JICA and ADB simultaneously. Furthermore, RGoB requested the Japan International Cooperation Agency (JICA) and Asian Development Bank (ADB) to cover the balance of fund requirements to achieve the targeted 'Electricity for all' by 2013.

1.2 Appointment and Terms of Reference

In order to conduct the Preparatory Survey, JICA appointed a consultant group comprising of the joint venture between Nippon Koei Co., Ltd. and ExeIdea Ltd.

The Terms of Reference for the Preparatory Survey for the Project are as follows:

(1) Examination of Project Background

1) Map existing and ongoing transmission/distribution lines and related facilities according to funding sources of each project.
2) Review the above data in conjunction with the RE master plan.
3) Examine impacts and lessons learned from past RE projects.

(2) Examination and Preparation of the Project Component

1) Review and summarize the results of existing surveys including that of ADB Project Preparatory Technical Assistance (PPTA), and conduct supplemental profile surveys in the possible targeted areas/villages of the Japanese official development assistance (ODA) loan.
2) Review and prepare details of electrification plan (routes, length and specifications of

transmission/distribution lines, locations of power substations, sources of supplies, etc.).

3) Review and prepare procurement plan and implementation scheme based on the experiences of the preceding project.
4) Prepare terms of reference for consultants that will assist in the implementation of the Project, including for construction supervision and capacity building for sustainable operation and maintenance (O&M).
5) Review the results of ADB PPTA on off-grid solar RE component and examine the possibility of implementing it under the loan scheme.

(3) Examination and Preparation of Environmental and Social Consideration Issues

1) Confirm necessary national/local environmental clearance for the implementation of the Project.
2) Examine the contents of the Initial Environmental Examination (IEE)/Environmental Impact Assessment (EIA) prepared by ADB consultant and confirm environmental category of the Project in light of the 'JBIC Guidelines for Environmental and Social Considerations (2002)'.
3) Examine and prepare mitigation measures for negative impacts of environmental and social consideration aspects, if any.

(4) Proposal for Sustainable O&M of the Project

1) Review the current O&M schemes for transmission/distribution lines.
2) Propose sustainable O&M schemes, equipment/facilities necessary for sustainable O&M of the RE facilities, and capacity building assistance schemes.

(5) Estimation of Project Cost

1) Estimate cost required to implement the Project, i.e., costs for procurement, transportation and construction of transmission/distribution lines and distribution substations, procurement of O&M equipment and facilities, consulting services, and necessary physical contingencies.

(6) Examination of Project Impacts

1) Identify economic/financial costs and benefits based on sensitivity analyses, and evaluate economic internal rates of return of the Project.
2) Assess qualitative as well as quantitative impacts on poverty reduction and regional development based on the profile survey results in the targeted areas.
3) Assess the impacts of applying the Project as a clean development mechanism (CDM) project.
4) Assess other possible qualitative impacts based on the observations of past RE projects with reference to the profiles of the targeted areas.

5) Set-up operations and effects indicators, considering monitoring feasibility, through the observations of past RE projects, and discussions with the Executing Agency/Implementing Agency (EA/IA).

(7) Implementation Program

1) Formulate the implementation program of the Project which consists of the summary of findings during the survey as well as the findings of PPTA of ADB.

1.3 Survey Team

The JICA Preparatory Survey Team (JPST) consists of seven members as listed below.

Table-1.3.1 Members of the Preparatory Survey Team

No.	Name	Title
1	Yoshiyuki KUDO	Team Leader/Rural Electrification
2	Akio SHIOTA	Photovoltaic Power Generation (First site survey only)
3	Toshinari UEMURA	Rural Electrification (2) (Replacement of Mr. Shiota, Joined to the team from 2nd site survey)
4	Hiroshi NISHIMAKI	Economic and Financial Analysis
5	Tomoaki TANABE	Environmental Assessment
6	Akiko NISHINOMIYA	Social Development
7	Takemi SATO	GIS Database / Material & Equipment Planning

(Prepared by JPST)

1.4 Major Activities

The JPST conducted its first site work from April 29, 2010 to June 23, 2010. The second site work was done from July 29, 2010 to August 29, 2010. The third site work was undertaken in Thimphu from October 27 to November 7, 2010.

The overall schedule of the study is as follows:

Table-1.4.1 Reports and Coordination Meeting with PPTA

No.	Reports / Coordination Meeting	Period
1	Inception Report	May 2010
2	Coordination Meeting with PPTA	May 2010
3	Draft Final Report	November 2010
4	Final Report	November 2010

(Prepared by JPST)

During the first site work, the following activities were carried out:

1) Holding of the inception meeting;
2) Holding of the coordination meeting (ADB);

3) Contracting out of local consultants for village survey, environmental and social economic survey, SHS survey, existing motorable road survey, and survey on future communication plan;
4) Data arrangement on GIS mapping; and
5) Basic data collection.

During the second site work, the following activities were carried out:

1) Review/confirmation of the GIS mapping data;
2) Preparation of project component;
3) Estimation of material quantities and project costs;
4) Study of project effects;
5) Finalization of mitigation measure on environmental/social considerations; and
6) Study on distribution system operation.

1.5 Acknowledgement

We gratefully acknowledge the cooperation and assistance of the Department of Energy (DOE), Bhutan Power Corporation (BPC) and other concerned organizations in Bhutan. The survey was accomplished through the full collaboration among the JPST, DOE, BPC and local consultants. The people directly involved in the survey from DOE and BPC dedicated themselves to the survey work and the local consultants made sincere efforts to accomplish their duties.

DOE:

Mr. Yeshi Wangdi (Director General)
Mr. Satchi Dukpa (Deputy Executive Engineer, Renewable Energy Division)
Mr. Karma P. Dorji (National Project Manager, Planning & Coordination Division)
Mr. Ngawang Choeda (Project Manager, Rural Electrification Project)
Mr. Mewang Gyeltshen (Chief Engineer, Renewable Energy Division)
Mr. Ugyen (Engineer, Renewable Energy Division)

BPC:

Mr. Bharat Tamang Yonzen (Managing Director)
Mr. Sunil Rasaily (Senior Manager, Corporate Planning & Business Development Unit)
Mr. Suresh Nepal (General Manager, Rural Electrification Department)
Mr. Drukehu Dorji (ADB Project Manager, Rural Electrification Department)
Mr. Tshering Tenzin (JICA Project Manager, Rural Electrification Department)
Mr. Dorji Namgyel (Engineer, Engineering & Design Division)
Mr. Nawaraj Chhetri (Senior Engineer, Distribution & Customer Services Department)
Mr. Norbu Tshering (Senior Project Manager, Development & Construction Department)

Mr. Raju Gurung (Manager, Central Store Division, Procurement Services Department)
Mr. Chador Phuntsho (Manager, Electricity Services Division)
Mr. Khandu Dorjee (Regional Manager, Electricity Services Division)
Mr. Chhejay Wangdi (Manager, Wangduephodrang)
Mr. Gempo Jampel (Manager, Planning & Monitoring Unit)
Mr. Gorab Dorji (Senior Engineer, Engineering Design & Contracts Department)
Mr. Pradeep M. Pradhan (General Manager, Procurement Services Department)
Mr. Dhanapati Dahal ((MEngSt) Manager)
Ms. Deki Yangzom (JICA Project Manager, Rural Electrification Department)
Mr. Karma Wangchuk (Senior Manager, Procurement Services Department)

In addition, we gratefully acknowledge the full cooperation and support of the staff in JICA Headquarters and JICA Bhutan Office.

CHAPTER 2 PRESENT STATUS OF POWER SECTOR

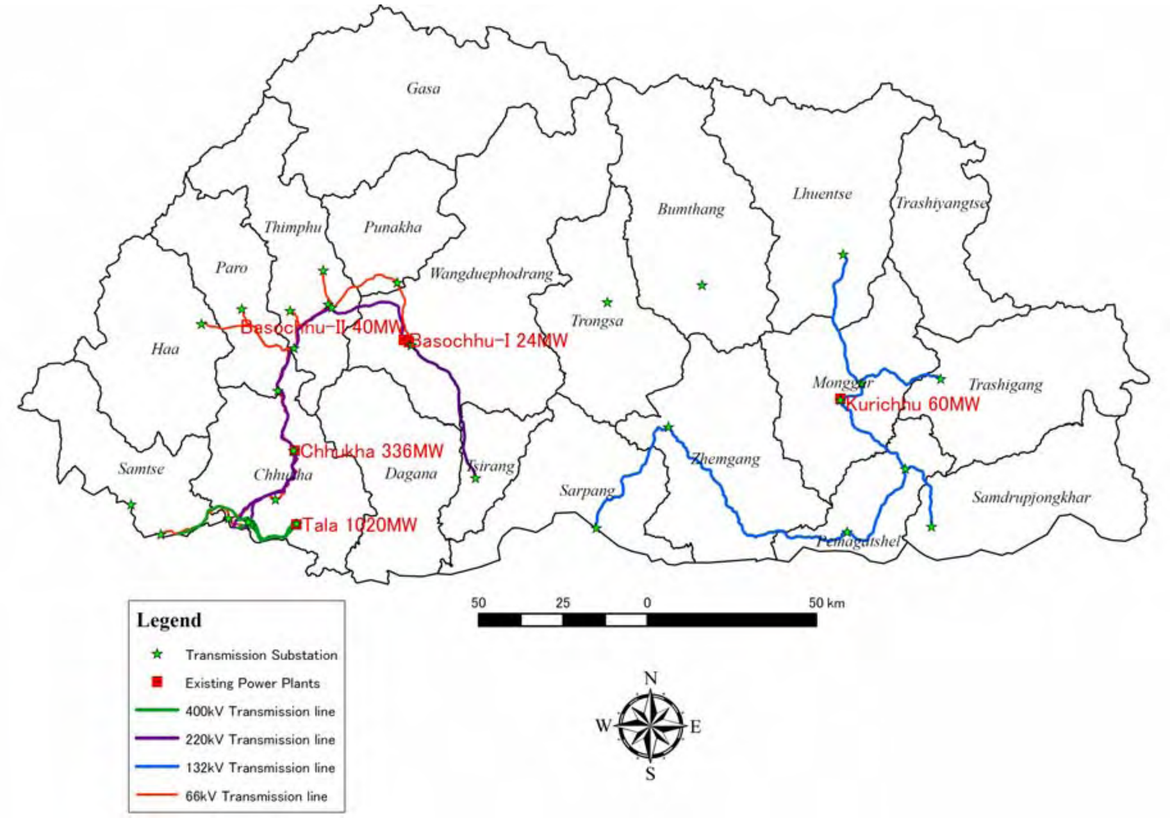
2.1 Present Status of Power Sector

2.1.1 Current Power Systems

(1) General

Bhutan, despite being landlocked and one of the least developed countries, is blessed with abundant natural resources, especially hydro and biomass resources. These energy resources hold an important position in the country's economy. Currently, hydropower is the main resource for electricity generation that caters to domestic energy needs as well as helps to earn revenues by way of export of electricity. On the other hand, biomass, in the form of fuel-wood, is the main resource for meeting residential energy demands such as cooking and space heating. According to the JICA Integrated Rural Energy Master Plan Study, the rural areas' consumption of firewood per capita is 3.95 kg per day, corresponding to 1.27 tons per year. The effective use of firewood and charcoal is thus recommended since the reduction of firewood consumption directly affects the preservation of forest resources. Rural electrification is expected to help in reducing firewood consumption in rural areas thereby facilitating better management of forest resources.

Due to the large altitudinal difference and swift flowing rivers, hydropower is considered the greatest natural resource in Bhutan for electricity generation with an estimated potential of 30,000 MW. As per the updated Power System Master Plan, 23,760 MW has been identified so far and assessed to be technically feasible. Most of the schemes identified are run-of-river types with minimal environmental impact. The power sector is solely dominated by hydropower with the present installed capacity of about 1,488 MW with five major hydropower project. In addition to the power generation infrastructures, transmission lines of 400 kV, 220 kV, 132 kV and 66 kV form other major power infrastructures for evacuation of power from the above stated power generating plants. These power system facilities including the major generation and high voltage transmission infrastructures are shown in Figure-2.1.1.



(Source: BPC)

Figure-2.1.1 Bhutan Power Facilities-Existing as on 2009

(2) Generating Facilities

Approximately 99.99% of the generating capacity in Bhutan is hydropower as summarized in Table-2.1.1. The technology for harnessing hydropower is not a new concept in Bhutan since the exploration of hydro resources started back in the 1960s with the commissioning of a 360-kW installed capacity mini hydro plant at Jushina, Thimphu. Since then, 31 hydro plants of various sizes ranging from 8 kW (micro hydro) to 1,020 MW (mega hydro) such as the Tala Hydropower Project with the above-stated total installed capacity of over 1,488 MW have been installed all over Bhutan.

The power/energy sector experienced a big change in generating capacity with the commissioning of the first 170 MW unit of the Tala Hydroelectric Project on July 29, 2006. This 1,020 MW project was fully commissioned by March 30, 2007. The generation of energy has increased to 4,520.4 GWh (where 99.96% is hydro-based generation) during 2006-07 from 2,647.4 GWh (where 99.9% is hydro-based generation) in the previous year. The energy generation in the subsequent years of 2007-08 and 2008-09 are 6,562.4 GWh (where 99.9% is hydro-based generation) and 6,960.8 GWh (where 99.9% is hydro-based generation), respectively[1]. A major share of the hydro electricity generated in the country is exported to India and the RGoB earns substantial revenue from it.

[1] Source: DOE's Power Data Book, 2009

Four micro/mini hydropower plants located in Thinleygang (30 kW installed capacity), Yadi (30 kW installed capacity), Surey (70 kW installed capacity) and Khaling (600 kW installed capacity) were decommissioned/shut down since they were damaged by flood after operation of over 18 years. The grid power supply has been provided to these places after the decommissioning/shutdown of the micro/mini hydropower sources.

Table-2.1.1 Existing Generating Facilities

Generating Type	Name of Plant (Owner)	District (Region)	Installation (MW)	Commissioned Year	Production(08-09) (GWh/annum)
Hydro					
Major-hydro	Chukha (DGPC)	Chukha (Western)	336	1986~88	1767.7
	Kurichu (DGPC)	Mongar (Eastern)	60	2001~02	375.9
	Basochu-I (DGPC)	Wangdue (Western)	24	2002	115.7
	Basochu-II (DGPC)	Wangdue (Western)	40	2004	206.3
	Tala (DGPC)	Chukha (Western)	1020	2006-2007	4473.1
Mini/Micro-hydro	- (BPC)	Whole Country	8.1	-	21.8
	Total		**1488.1**		**6960.5**
Diesel					
	BPC	Whole Country	9.2	1966~2001	0.17
	Others	Whole Country	8.2	1981~2008	0.18
	Total		**17.4**		**0.35**
Solar					
	Total		**0.03**		Not available
	Grand Total		**1505.5**		**6960.9**

(Source: Power Data Book 2008-09, DOE)

(3) Transmission Line Facilities

Table-2.1.2 summarizes the present transmission line facilities in the country.

Table-2.1.2 Major Existing Transmission Line Facilities (As of end 2009)

Voltage	Sections	length (km)	OPGW	Conductor
400 kV	Tala – India Border at Khogla (D/C)	24.6		Moose x2
400 kV	Tala – Malbase – India Border at Pugli (D/C)	49.5		Moose x2
220 kV	Chukha - Birpara (D/C) (interconnection with India) (Chukha – Gedu - India border)	71.2 (35.8)	No	Zebra
220 kV	Chukha – Gedu - Malbase (S/C)	29.8	No	Zebra
220 kV	Chukha – Simtokha (S/C)	54.01	No	Zebra
220 kV	Semtokha – Rurichu (S/C)	44.9	Yes (BPC own)	Zebra
220 kV	Rurichu – Dharjay,Tsirang (S/C) - currently charged at 66kV	46.6	Yes	Zebra
220 kV	Malbase – India border (Birpara) (S/C)	4.1	No	Zebra
220 kV	Malbase – Singhigaon-Fdr-I (S/C)	1.7	No	Zebra
220 kV	Malbase – Singhigaon-Fdr-II (S/C)	2.6	No	Zebra
132 kV	Kurichu (Gyelposhing) - Kilikhar (Mongar)	10.1	No	Panther
132 kV	Kilikhar (Mongar) - Kanglung (Trashigang)	29.6	No	Panther
132 kV	Kilikhar (Mongar) – Tangmachu (currently charged at 33kV)	42.8	No	Panther
132 kV	Kurichu (Gyelposhing) - Nangkhor (Pemagatshel)	31.0	No	Panther
132 kV	Nangkhor (Pemagatshel) - Deothang	23.3	No	Panther
132 kV	Nangkhor - Nanglam	34.07	No	Panther
132 kV	Nanglam - Tintibi	83.33	No	Panther
132 kV	Tintibi - Gelephu	45.74	No	Panther
132 kV	Gelephu - Salakati (interconnection with India) (Gelephu – India Border)	50.0 (0.1)	No	Panther
132 kV	Deothang – Motanga (S/C)	10.5	No	Panther

Voltage	Sections	length (km)	OPGW	Conductor
	(Motanga – India Border)	(1.5)		
66 kV	Chukha - Gedu	20.4	Yes (BT own)	Dog
66 kV	Gedu - Phuentsholing	16.7	Yes (BT own)	Dog
66 kV	Phuentsholing - Singhegaon	8.99	Yes (BT own)	Dog
66 kV	Malabase – Pasakha Multi Circuit	3.41	No	Dog
66 kV	Phuentsholing - Gomtu	26.9	No	Dog
66 kV	Chukha - Tie-line(of Watsa) - Chumdo (Confluence)	36.98	Yes (BT own)	Dog
66 kV	Tie-line - Watsa	0.5	Yes (BT own)	Dog
66 kV	Chumdo (Confluence) - Haa	33.4	No	Dog
66 kV	Chumdo (Confluence) - Paro	24.01	Yes (BT own)	Dog
66 kV	Chumdo (Confluence) - Kasadrapchu - Olakha	17.52	Yes (BT own)	Dog
66 kV	Kasadrapchu – Jenima (D/C)	5.96	No	Dog
66 kV	Olakha - Simtokha	1.7	Yes (BT own)	Dog
66 kV	Simtokha - Dechencnoling	11.45	No	Dog
66 kV	Simtokha - Lobesa	24.33	No	Dog
66 kV	Lobesa – Rurichu (near Basochu II P/S)	20.1	No	Dog
66 kV	Hebisa (near Basochu I P/S) – Rurichu (near Basochu II P/S)	3.1	No	Dog
66 kV	Trongsa –Yurmo (currently charged at 33 kV)	20.94	No	Wolf

Note: Zebra, Panther, Wolf, Dog = Conductor Codes of British Standards

(Source: BPC)

At present, the highest transmission voltage operated in Bhutan is 400 kV. The 400 kV lines connect the Tala Power Plant to the Indian grid by two double circuit systems from Tala via Tala - Khogla and Tala – Malabase - Pugli. The total length of the 400 kV transmission line within Bhutan is 74.143 km (double circuit).

The 220 kV lines are operated between the Chukha Hydropower Station and Simtokha Substation near Thimphu in the western system, in Simtokha–Rurichu–Tsirang, as well as along the export-use line from the Chukha Hydropower Station to the Birpara Substation in India. The other 220 kV lines are along CHP-Gedu-Malbase, Malbase-India Border (Birpara) and Malbase to Singhigaon. The total length of 220 kV transmission lines is 183.74 km (single circuit) and 35.78 km (double circuit).

The power transmission system in Bhutan is separately operated as a 132 kV transmission system in the eastern-central region and as a 220 kV transmission system in the western region. The two systems have not been interconnected yet. However, wheeling power flow between the two systems is possible with the interconnection of the lines through Bhutan and the northeast part of India. The plan to interconnect these systems is underway. The 220 kV line, which has reached Dhajay, Tsirang (now charged at 66 kV), is being extended to Jigmeling between Sarpang and Gelephu by BPC. A 220/132 kV substation work is already awarded by BPC for immediate construction. The existing 132 kV line connecting Kurichu Power at Gelephu via Tingtibi will be extended from Lodrai, Gelephu to the 220/132 kV Jigmeling Substation for the interconnection.

The total length of the 132 kV line is 312 km (single circuit). The 66 kV transmission lines are also running mostly in the western region in 17 sections with total lengths of 267.2 km (single circuit), 5.96 km (double circuit) and 3.405 km (quadruple circuit).

Bhutan transmission lines apply particular facilities of high insulation level since high altitude decreases the insulation strength of facilities. The conductors used for all transmission lines are standard aluminum conductor steel reinforced (ACSR). It is peculiar that conductors adopt unique sizes according to voltages. In British standards, Moose conductor (500 mm^2) is used for 400 kV lines, Zebra conductor (400 mm^2) is used for 220 kV lines, Panther (200 mm^2) for 132 kV lines, and Dog (100 mm^2) for 66 kV lines. In order to increase transmission capacity as well as economize in construction cost, it is deemed that conductors of various sizes should be examined for selecting the most appropriate size for each transmission line. Another feature of transmission lines in Bhutan is that lines ought to be routed in steep and mountainous land resulting in more angled and less tangential towers, which increases construction costs.

In order to protect power conductors from lightning strikes, overhead ground wires are installed above conductors over the entire length of the lines. Most of the existing overhead ground wires installed for the 66 kV lines in the western system have been replaced with optical fiber composite overhead ground wire (OPGW) that has optical fiber, which is capable of transmitting huge quantities of information.

(4) High Voltage Substations

Technical elements of high voltage (HV) substations related to the above transmission lines are shown in Table-2.1.3. There are ten substations with a total installed capacity of 207 MVA in the eastern-central system as of December 2009. There are 23 substations with a total installed capacity of 2,785.3 MVA in the western system. All existing HV substations have conventional layout and are outdoor-type, except those annexed to power stations. Operation of transmission lines and substations is controlled through power line carrier (PLC) by the 132 kV Kilikhar Substation in the eastern system, 220 kV Simtokha Substation for the northern half of the western system, and 220 kV Singhegaon Substation for the southern half of the western power system.

Table-2.1.3 Existing Substations (above 66 kV) (As of end 2009)

No.	Station	Voltage Ratio (kV)	Transformers		Total Capacity (MVA)
			Nos.	Capacity (MVA)	
1	Chukha P/S	11/220	12	35	420
2	Chukha	220/66	2	20	40
		66/11	3	3	9
3	Singhegaon	220/66	1	50	50
		220/66	2	35	70
		66/11	1	5	5
		66/11	1	10	10
4	Pasakha (BCCL)	66/11	2	20	40
5	Pasakha (BFAL)	66/11	1	28.5	28.5
		66/11	1	20	20
6	Gomtu	66/33	1	5	5
		66/11	1	5	5
		66/11	1	3	3
7	Penden (PCAL)	66/6.6	2	5	10

No.	Station	Voltage Ratio (kV)	Transformers		Total Capacity (MVA)
			Nos.	Capacity (MVA)	
		66/6.6	1	6.3	6.3
8	Phuentsholing	66/33	2	10	20
		66/11	2	3	6
		66/11	1	12.5	12.5
9	Gedu	66/33	2	8	16
		66/11	2	5	10
10	Olakha	66/33/11	2	20	40
11	Simtokha	220/66	6	6.67	40
		66/11	2	10	20
12	Paro	66/33/11	1	2.5/2.5	5
		66/33	1	10	10
13	Haa	66/11	2	5	10
14	Lobesa	66/33	1	5	5
		66/11	2	5	10
15	Gelephu	132/66	2	25	50
		66/11	1	10	10
		66/33/11	2	2.5/2.5	10
16	Watsa	66/33	1	5	5
17	Deothang	132/33	2	5	10
18	Nangkor	132/33	2	5	10
19	Tintibi	132/33	2	3	6
20	Kilikhar	132/33	2	5	10
21	Kanglung	132/33	2	5	10
22	Nganglam	132/33	2	3	6
23	Basochu I P/S	11/66	2	15	30
24	Basochu II P/S	11/220	2	30	60
25	Rurichu	220/66	1	30	30
		66/11	1	5	5
26	Kurichu P/S	11/132	4	20	80
27	Kurichu	132/11	1	5	5
28	Jemina	66/33	1	10	10
29	Tangmachu *	33/11	2	1.5	3
30	Dechencholing	66/33	2	10	20
31	Malbase	400/220	3	40/53.35/66.67	200
		220/66	3	50/63	189
		66/11	2	20	40
32	Tala	13.8/400	18	70	1260
33	Dajay **	66/33	2	5	10
	TOTAL				**2995.3**

*: The structure is designed for 132 kV but charged in 33 kV.

**: The structure is designed for 220 kV but charged in 66 kV.

(Source : Power Data Book 2009, BPC & Power Data Book 2008-09 (DOE))

NLDC would be functioned as a control center with Supervisory Control and Data Acquisition (SCADA) system, hence all hydro power stations and 66kV and above substations in Bhutan would be connected through the OPGW backbone network to the NLDC in Thimphu.

The OPGW backbone network would have enough capacity to transmit all kinds of data and information such as management, financial, administrative, operation and maintenance. Hence, the GIS data will be commonly utilized at the national level.

(5) Distribution Facilities

Sub-transmission distribution lines of 33 kV and 11kV are commonly used to draw power from transmission substations to villages and other load centers. Power/electricity is supplied to low voltage (LV) consumers at 400 V, 3-phase supply and 230 V single phase supply through distribution transformers, LV lines and service connections. The 6.6 kV voltage system is also used in isolated mini/micro hydropower supplying to off-grid areas. The lengths of the 6.6 to 33 kV medium voltage (MV) lines and 400 V LV lines in each district (dzongkhag) are described in Table-2.1.4. The total length of MV lines is approximately 3,000 km and that of LV lines is over 4,200 km.

Table-2.1.4 Existing Distribution Facilities in Each Dzongkhag (As of end 2009)

No.	Dzongkhag	Line Length (km) (including OH and UG lines)					Total line length (km)	Nos of DL TRs	Installed Capacity (kVA)
		33 kV	11 kV	6.6 kV	Total MV line length (km)	LV lines (km)			
1	Bumthang	43.5	54.9(0.2)*1	6.9	105.3(0.2)	84.9(1.6)	190.3(1.8)	65	8,224
2	Chukha	66.0	112.5(10.1)	0.0	178.4(10.1)	325.5(77.9)	503.9(88.0)	137	40,337
3	Dagana	26.4	0.0	45.3	71.7	57.5	129.2	32	2,823
4	Sarpang	0.0	171.3	0.0	171.3	322.5	493.7	106	14,618
5	Haa	32.5	68.4	0.0	100.9	169.6	270.5	78	8,499
6	Lhuntse	28.7	98.3	0.0	127.0	104.0	231.0	70	4,443
7	Mongar	107.5	100.4(0.1)	0.0	207.9(0.1)	315.1(0.2)	523.0(0.3)	102	9,370
8	Paro	108.2	176.8(2.2)	0.0	285.0(2.2)	358.5(4.5)	643.4(6.7)	163	35,420
9	Pemagatsel	107.3	18.1	0.0	125.3	208.3(1.6)	333.7(1.6)	90	6,149
10	Punakha	155.6	38.8(0.6)	0.0	194.5(0.6)	292.2(3.7)	486.6(4.3)	140	12,682
11	Samtse	28.6	144.1	0.0	172.7	281.2(0.3)	453.9(0.3)	118	14,131
12	Samdrup Jongkhar	65.5	52.2	0.0	117.7	114.1	231.8	83	12,538
13	Thimphu	86.4	211.8(47.3)	14.4	312.6(47.3)	339.7(75.9)	652.2(123.2)	300	125,173
14	Trongsa	9.9	14.7	2.3	26.8	44.1	70.9	29	5,604
15	Trashigang	74.5	254.3	0.0	328.8	565.6(0.8)	894.5(0.8)	194	15,582
16	Trashiyangtse	113.6	7.0	0.0	120.6	223.4(2.0)	344.0(2.0)	80	6,061
17	Tsirang	0.0	0.0	8.0	8.0	13.4	21.4	15	1,355
18	Wangdue	133.3	98.5	1.2	232.9	355.2(3.2)	588.1(3.2)	148	16,354
19	Zhemgang	79.4	9.6	21.0	110.0	62.6(1.6)	172.6(1.6)	34	3,531
	Total	1,266.9	1,631.7 (60.5)	99.1	2,997.4 (60.5)	4,237.4 (173.3)	7,234.7 (233.8)	1,984	342,894

Note: Gasa Dzongkhag does not have Electricity Services Division (ESD). The line length of Gasa is included in the data of Punakha. OH: overhead. UG: underground. MV: medium voltage. LV: low voltage.

*1 The figures in parentheses indicates the length of underground lines which is included in each line length

(Source: Power Data Book 2009, BPC, Power Data Book 2009, DOE)

2.1.2 Demand and Supply Balance

(1) Past Records of Balance

Table-2.1.5 shows the actual performance of electricity supply and demand in Bhutan from 2002 to 2009. Total installed capacity of power generation, excluding photovoltaic (PV)/solar facilities, is over 1,488 MW as against the system peak power demand of 211 MW in the year 2008-09. Hydropower sources share 98.8% of the total installed capacity. The total generated energy in 2008-09 was over 6,960 GWh. In contrast, the total energy requirement for the whole country in 2008-09 was about 1,368 GWh, including the system energy losses. Thus, the supply for the country has sufficient surplus for both peak power and energy demands, although importation of electric energy was needed in some areas where the on-grid distribution system from domestic electricity sources has not yet been facilitated. Imported electricity is also needed in some areas where domestic supply is short during the dry season.

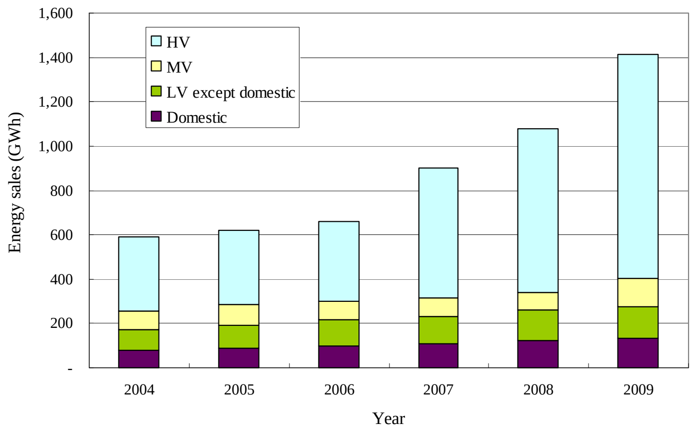
Bhutan exports the surplus energy to the Indian grid at mutually agreed rates between the two governments and earns substantial revenue. Total exported electric energy was 5,609 GWh in the year 2008-09, which was equivalent to 4.1 times of the total electric energy required in the same year in the whole of Bhutan.

Table-2.1.5 Power and Energy Balance in Bhutan (2003-2009)

Particulars		Year					
		2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Installation Capacity of Generation (MW/year)	Hydro	428.6	468.6	468.1	1488.2	1488.2	1488.1
	Diesel	16.4	16.4	14.6	17.2	17.4	17.4
	PV Solar	0.2	0.2	0.2	0.4	0.0	0.0
	Total	445.0	485.0	482.7	1505.3	1505.6	1505.5
Domestic Peak Demand (MW)		112.0	120.0	128.0	157.0	194.0	211.0
Energy Generation (GWh/year)	Hydro	2526.6	2353.2	2645.8	4518.6	6560.4	6960.5
	Diesel	2.1	1.8	1.5	1.8	2.0	0.4
	Total	2528.7	2355.0	2647.4	4520.4	6562.4	6960.8
Energy Import (GWh/Year)		18.7	21.0	34.1	11.1	7.3	16.7
Total Energy Consumption in the Country including Losses and Auxiliary Supplies (GWh)		702.9	752.3	738.1	887.8	1140.5	1368.2
Total Hydro Energy Export to Indian Grid (GWh/year)	Chukha HP	1553.7	1341.4	1644.0	1888.6	1851.2	1833.0
	Kurichu HP	290.8	282.2	299.4	270.6	199.5	183.8
	Tala HP	-	-	-	1484.5	3378.4	3592.6
	Total	1844.5	1623.7	1943.4	3643.7	5429.1	5609.4

(Source：Power Data Book 2008-09, DOE)

Figure-2.1.2 shows the energy sales by voltage categories in Bhutan from 2004 to 2009. The average annual growth rate of the total energy sales from 2004 to 2009 was 19.8%. This was mainly caused by the growth of HV energy sales, which has 27.0% of the average annual growth rate.



(Source: Power Data Book 2009, BPC)

Figure-2.1.2 Energy sales by voltage categories

Table-2.1.6 shows the numbers of consumers by categories in Bhutan as of December 2009. Average annual growth rate of the number of consumers from 2004 to 2009 was 15%.

Table-2.1.6 Number of Consumers

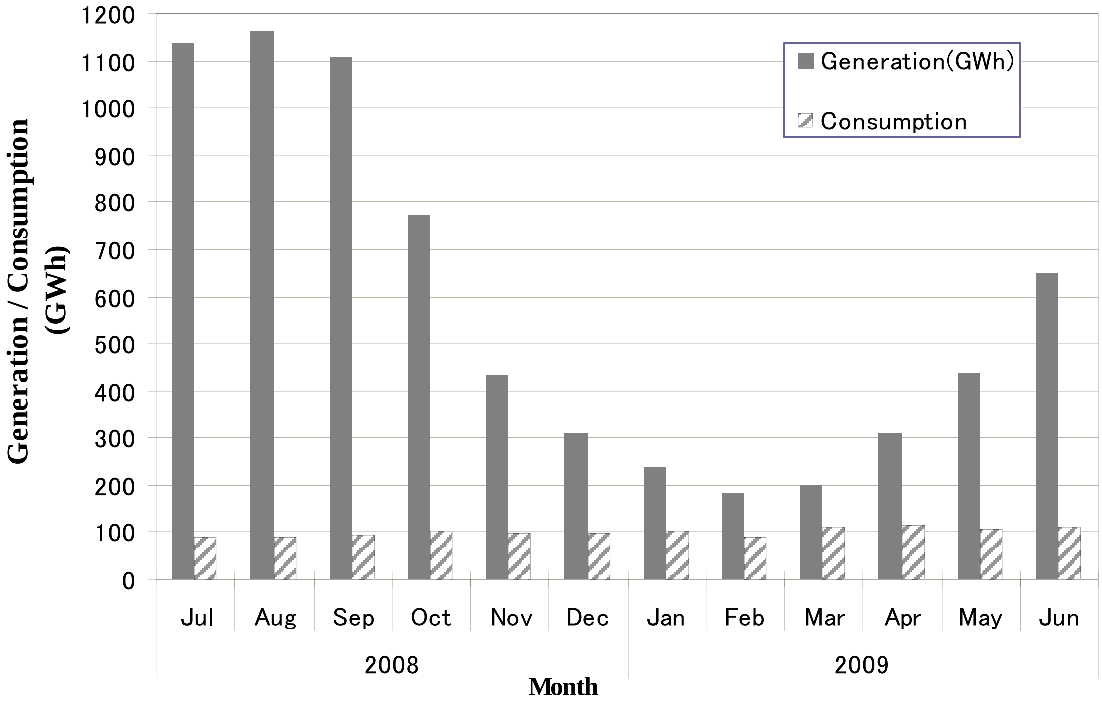
Voltage-wise	Domestic	Commerce	Industry	Agri-culture	Institution	Street Light	Bulk Supply	Others	Total
LV consumer	75,140	8,564	204	515	3,958	239	603	2,499	91,722
MV consumer	0	0	37	0	0	0	0	0	37
HV consumer	0	0	11	0	0	0	0	0	11
Total	75,140	8,564	252	515	3,958	239	603	2,499	91,770

(Source: Power Data Book 2009, BPC)

(2) Seasonal and Daily Characteristics of Supply and Demand

1) Seasonal Characteristics

As previously mentioned, approximately 99.9% of electricity in Bhutan is generated by hydropower stations, which are run-of-river types. Accordingly, the amount of generated energy of these power stations declines during the dry season from December to April due to less water inflow. Figure-2.1.3 shows the total monthly energy production of the five major hydro stations from July 2007 to June 2009 and the energy consumption over the same period in Bhutan. The balance between production and consumption, i.e., surplus after consumption in the country, was exported to India.



(Source: DOE)

Figure-2.1.3 Monthly Energy Generation and Consumption in Bhutan

The figure indicates the tendency of increasing energy consumption during the winter season when the demand increases for heating needs and water inflow into the power stations becomes less. It is obvious that there is a sufficient surplus in the total annual energy production, but seasonal energy surplus is extremely varied. All large-scale hydropower stations that are being constructed and planned are run-of-river types. On this account, it is evident that such seasonal fluctuation of energy production and consumption will continue. Since the production capacity of the planned power stations is huge against the demand growth of the country, such seasonal fluctuation is deemed not very serious in the future. However, particular countermeasures for the seasonal output fluctuation should be carefully studied in the eastern power system, having smaller development plan of power stations.

2) Daily Load Curves

Daily load data covering the whole country is not available at present. Figure-2.1.4 indicates typical daily load curves in Thimphu for January (winter, dry season) and June (summer, rainy season) 2009. The figures show loadings on a holiday (Sunday) and on a working day (Monday) for comparison.

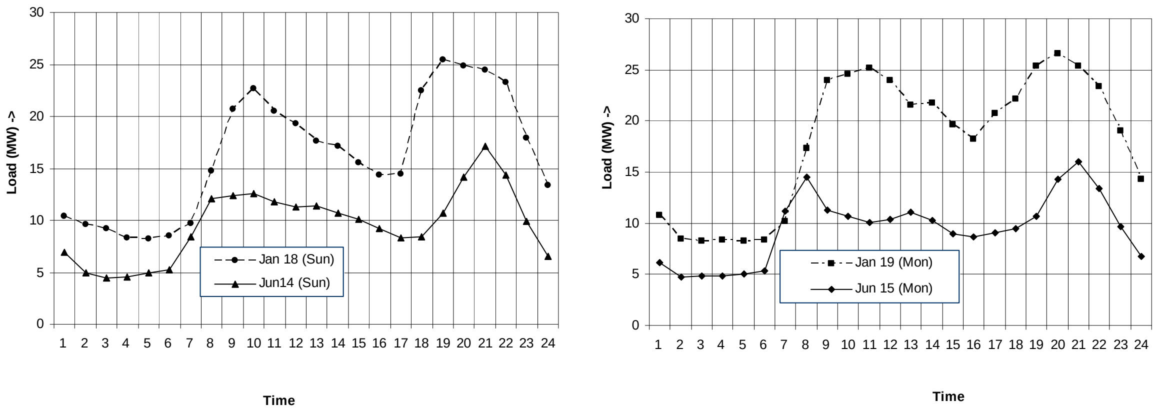


Figure-2.1.4 Daily Load Curve (Thimphu, 2009)

(Source: Power Data Book 2009, DOE)

In Thimphu, domestic (household) demand shares most of the total demand (53%), while industrial demand shares only about 2%. In any case, two daily peaks (morning and evening) appear. This seems to be a typical urban scenario. Demand during the winter season is almost double that during summer. Demands on Sunday and Monday during the winter season are similar in timing and loading. It is believed that heating facilities are popular in Thimphu. The load factor in Thimphu (load factor = average power demand / maximum power demand) is 60-70%, which is higher than in the rural areas.

(3) System Energy Loss

The Power Data Book 2008-2009 issued by DOE reports the following system energy losses in the whole country as described in Table-2.1.7, including those of transmission and distribution lines, distribution networks, and other power facilities.

Table-2.1.7 Energy Losses in Bhutan

(Unit: GWh/year)

	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Energy Requirement	659.8	673.5	738.7	729.6	832.9	1118.4	1278.5
Energy Loss	88.5	93.4	116.5	108.7	66.2	128.6	75.8
Loss Rate (%)	13.4	13.9	15.8	14.9	7.9	11.5	5.9

(Source: Power Data Book 2008-09, DOE)

Although no statistics of energy losses is produced in each facility of transmission and distribution line system, the losses in the distribution network are considered to be significant. The losses are decreased in the newly constructed distribution facility of ADB/RE-1, ADB/RE-2, RE3 and JICA RE-1. However, on the rural electrification (RE) starting from the expansion of existing lines, the losses will increase since larger current is expected to pass through the existing lines. For the formulation of the grid extension plan, therefore, it would be necessary to include the improvement of the existing facilities and upgrading of existing distribution lines. To decrease distribution losses, upgrading of conductor size is the most effective measure to improve the supply voltage to the customers, because distribution losses are mainly due to the excessive voltage drop.

2.1.3 Electricity Tariff

(1) Electricity Tariff System

Electricity tariff is revised from time to time, usually on an annual basis, with the approval of Bhutan Electricity Authority (BEA), an autonomous organization established as per the Electricity Act of Bhutan 2001 to regulate the electricity supply industry of Bhutan.

A flat domestic tariff system per unit of electricity consumption for rural and urban areas existed in the country up to January 1, 2003. Thereafter, the slab/block tariff system according to voltage level has been introduced. The chronological electricity tariff schedule from January 1, 2003 to July 31, 2010 is as shown in Table-2.1.8 below.

Table-2.1.8 Electricity Tariff Table from Jan. 2003 to Jul. 2010

Date	Voltage Level		Block			Rate/kWh
01-Jan-03 till 30-Jun-04	Low voltage		<=80 kWh	per month		0.60
			>=81 kWh<=200	per month		0.90
			>=201 kWh	per month		1.00
	Medium voltage(6.6/33/11 kV)					0.95
	High voltage(66 kV and above)					0.90
1-Jul-04 till 30-Jun-05	Low Voltage		<=80 kWh	per month		0.60
			>=81 kWh<=200	per month		0.95
			>=201 kWh	per month		1.20
	Medium voltage(6.6/11/33 kV)	Demand charge = Nu. 54 /kW/Month			Energy Charge=	0.95
	High voltage (66 kV and above)	Demand charge = Nu. 54 /kW/Month			Energy Charge=	0.90
1-Aug-05 till 30-Jun-06	Low Voltage		<=80 kWh	per month		0.60
			>=81 kWh<=200	per month		1.10
			>=201 kWh	per month		1.30
	Low Voltage Bulk Customers					1.25
	Medium voltage(6.6/11/33 kV)	Demand charge = Nu. 54 /kW/Month			Energy Charge=	1.10
	High voltage (66 kV and above)	Demand charge = Nu. 54 /kW/Month			Energy Charge=	1.05
1-Jul-06 till 30-Jun-07	Low Voltage		<=80 kWh	per month		0.70
			>=81 kWh<=200	per month		1.20
			>=201 kWh	per month		1.45
	Low Voltage Bulk Customers					1.35
	Medium voltage(6.6/11/33 kV)	Demand charge = Nu. 54 /kW/Month			Energy Charge=	1.25
	High voltage (66 kV and above)	Demand charge = Nu. 54 /kW/Month			Energy Charge=	1.20
1-Jul-07 till 30-Jun-08	Low Voltage		<=80 kWh	per month		0.75
			>=81 kWh<=300	per month		1.25
			>=301 kWh	per month		1.55
	Low Voltage Bulk Customers					1.55
	Medium voltage(6.6/11/33 kV)	Demand charge = Nu. 65 /kW/Month			Energy Charge=	1.30
	High voltage (66 kV and above)	Demand charge = Nu. 65 /kW/Month			Energy Charge=	1.29
1-Jul-08 till 30-Jun-09	Low Voltage		<=80 kWh	per month		0.75
			>=81 kWh<=300	per month		1.35
			>=301 kWh	per month		1.70
	Low Voltage Bulk Customers					1.70
	Medium voltage(6.6/11/33 kV)	Demand charge = Nu. 75 /kW/Month			Energy Charge=	1.43
	High voltage (66 kV and above)	Demand charge = Nu. 75 /kW/Month			Energy Charge=	1.40
1-Jul-09 till 31-Jul-10	Low Voltage		<=80 kWh	per month		0.75
			>=81 kWh<=300	per month		1.40
			>=301 kWh	per month		1.85
	Low Voltage Bulk Customers					1.85
	Medium voltage(6.6/11/33 kV)	Demand charge = Nu. 85 /kW/Month			Energy Charge=	1.55
	High voltage (66 kV and above)	Demand charge = Nu. 85 /kW/Month			Energy Charge=	1.51

(Source: Power Data Book 2008-09, DOE)

1) Domestic Tariff: BEA has recently approved the revision of electricity tariff to be charged to customers by BPC with effect from August 1, 2010 up to June 30, 2013 and posted it in its website on August 13, 2010, the details of which is in Table-2.1.9.

Table-2.1.9 Tariff Table for Households and Other Consumers

Customer Category		1st August 2010 to 30th June 2011	1st July 2011 to 30th June 2012	1st July 2012 to 30th June 2013
Wheeling (Nu./kWh)		0.111	0.111	0.111
LV	0-100 kWh per month (Nu./kWh)	0.85	0.85	0.85
	101-300 kWh per month (Nu./kWh)	1.47	1.54	1.62
	Above 300 kWh per month (Nu./kWh)	1.94	2.04	2.14
	LV bulk consumers (Nu./kWh)	1.94	2.04	2.14
MV	Energy charge (Nu./kWh)	1.63	1.71	1.79
	Demand charge (Nu./kWh) /month	95	105	115
HV	Energy charge (Nu./kWh)	1.51	1.54	1.54
	Demand charge (Nu./kWh) /month	85	105	105

(Source: Bhutan Electricity Authority)

2) Export Tariff: Bhutan exports surplus generation of hydropower energy to the Indian grid at mutually agreed rates between the two governments. The present electricity export tariffs are Rs.2.00/kWh for electricity exported from Chukha Hydropower Plant, Rs.1.75/kWh for electricity exported from Kurichu Hydropower Plant, and Rs.1.80/kWh for electricity exported from Tala Hydropower Plant.

3) Import Tariff: The importation of some electric energy was needed in some areas where the on-grid distribution system from the domestic electricity sources has not been facilitated. The unit price of such imported electricity is Nu./Rs.2.20 and 12% loss is accounted for the State Electricity Boards of West Bengal and Assam.

For the consumers of power, the cost of using electricity arises not only from the monthly tariff but also from the initial connection charges and internal wiring. The connection charge is more than Nu.500 for single-phase users as they have to bear the actual cost of the meter. In addition, consumers have to cover the cost for internal wiring ranging from Nu.5,000 to Nu.15,000 depending on the size of the house. The wiring cost is somewhat equivalent to two to three months of income for low-income households. This cost may inhibit connection to electricity but such case is said to be very rare until now. The ADB/RE-3 program suggested providing free electrification kits to very poor households. The electricity connection cost is shown in Table-2.1.10.

Table-2.1.10 Electricity Connection Cost (As of Sep 2010)

No	Description	Rate (Nu.)
1	Meter Security	
	(a) For Three Phase meter	Actual Cost of Meter
	(b) For Single Phase meter	Actual Cost of Meter
2	Energy Security	
	(a) For Three Phase meter	36 x Ampere rating
	(b) For Single Phase meter	12 x Ampere rating

No	Description	Rate (Nu.)
3	Fixed Charge (meter and service cable connection charges, etc.)	
	(a) For Three Phase	150
	(b) For Single Phase	100
4	Installation Inspection & Testing Charges	
	(a) For Three Phase	300
	(b) For Single Phase	100
	Others	
1	Meter Shifting Charge	
	(a) For Three Phase	150
	(b) For Single Phase	100
2	Meter Testing Charge	
	(a) For Three Phase	100
	(b) For Single Phase	50
3	Reconnection Charges (for Payment default)	
	(a) For Three Phase	150
	(b) For Single Phase	100

(Source: BPC)

(2) Electricity Tariff Collection Method

BPC's local offices dispatch meter readers every month to check the meters of the consumers and to hand out the bills. The consumer needs to pay in cash at the Distribution and Customer Services Department (DCSD) of each BPC field office. The field offices of DCSD are available in each dzongkhag in the form of Electricity Services Division (ESD) or Electricity Services Sub-division (ESSD). Each field office is now equipped with a personal computer and database software for billing and collection.

A meter reader is typically assigned a certain geographical area as his area of responsibility. There are two different modes of the meter reading process, namely, once-a-month system and twice-a-month system. In the once-a-month system, the meter reader visits a household once a month to do the meter reading for the current month and to hand over the bill for the previous month. In this system, the meter reader has to pay one monthly visit to each household. However, revenue collection is delayed by two months. In the twice-a-month system, the first visit is during the last 10 days of a month for meter reading and the next visit is during the first 10 days of the next month for billing delivery. In this system, the revenue comes in faster but two visits are required leading to increased cost.

BPC has also tried the spot billing system as a pilot case in Thimphu. In this system, the meter readers with spot billing meters (SBMs) go and read meter and deliver bill at the same time. Even though this system includes the best features of the above two systems, the less costly SBMs ($400 apiece) were not robust enough and often failed. The more robust SBMs are very expensive at US$2,000 apiece. An average billing system, where consumers are billed based on past averages, was tried out but there was resistance from customers because they did not understand the average concept.

It is often the case for some consumers that the transportation to reach the BPC's field office costs more than the electricity bill. BPC has responded to this issue in some places by doing "collection at site". These sites have been selected by BPC on a case-by-case basis at the request of the community. Meter reader and cashier go to the community on a particular day of the month for the collection. However, this results in added expenditure for BPC. Further, RE would add more costs to local operations. Therefore, it is necessary to examine the ways to increase efficiency in tariff collection.

(3) Power Purchase from DGPC and Wheeling Charge

As mentioned in Table 2.1.1, Druk Green Power Corporation (DGPC) has five hydro generating facilities with a total installed capacity of 1,480 MW. All generated power of DGPC is transmitted through BPC-owned transmission lines mainly for power export to India and for domestic use within Bhutan. BPC is able to purchase the electricity from DGPC at a rate of NU 0.13/kWh for the first 15% of total generated power as a royalty price, and the remaining 85% at 1.2Nu/kWh as an additional price.

In the case of exporting power to India, DGPC has to pay a wheeling charge to the Transmission Department of BPC at a rate of 0.111Nu/kWh, which came into effect on August 1, 2010.

2.1.4 Power System Development Plan

(1) Candidate Sites for Future Hydropower Generation

The final report of the updated Power System Master Plan (PSMP) 2003 details the results of the review of previous PSMP on the candidate generation sites, which were studied by the same consultant in 1993. The main purpose of the development of new large-scale hydropower stations in Bhutan is to export energy to India and supply energy for domestic needs.

A total of 20 sites were at first selected from 76 candidate sites for development through a 9-step screening process. These 20 candidate sites were further reduced to 11 sites through the examinations of preliminary design, cost estimates and IEE. The remaining 11 sites were technically studied in terms of hydrological parameters such as annual discharge, firm discharge, and flood discharge, geological studies for tunnels, underground power stations, etc., as well as the environmental situation around the project. Applying the initial estimates for firm peak power/energy and seasonal energy production, PSMP conducts preliminary design of routes of construction access roads, scales of intake dams, tunnels, penstocks, powerhouses, tailrace, and other facilities for each candidate site. Transmission line facilities were preliminarily designed and by examining maps with a scale of 1:571,430, transmission line routes were also preliminarily selected. Based on these designs, construction cost for each candidate site was estimated. The development priority of the 11 candidate sites is ranked through a multi-criteria analysis by relevant personnel, considering economic, social, and environmental aspects. The analysis was made based on the economic evaluation results of the estimated energy production and the present value of the total cost of each candidate site, including construction and operation and maintenance costs. Based on the result, the 11 candidate sites were ranked according to development priority.

The RGoB's priority at that time was to upgrade the hydropower generation capacity to at least 5,000 MW by 2022. Accordingly, seven candidate sites consisting of five candidate sites and two sites requiring additional investigation were determined as priority sites to be developed by the year 2022. Table-2.1.11 indicates the outline of the ranked candidate sites as per the updated PSMP.

Table-2.1.11 Development Priority of Large-scale Hydropower Stations

Priority	Project	Dzongkhag	Type (*1)	Installed Capacity (MW)	Max. Output (MW)	Firm Power (MW)	Firm Peak Power (MW)	Mean Production (GWh/year)	Firm Peak Energy (GWh/year)	Construct. Schedule	Investment (10^6 US$)	EUCE (*2) (USc/kWh)
1	Punatsangchu-I	Wangdue-phodrang	ROR	1,002	973	168	920	4,770	1,343	2007-11	861.3	2.86
2	Mangdechu	Trongsa	ROR	670	651	92	535	2,909	782	2009-13	587.7	3.23
3	Punatsangchu-II	Wangdue-phodrang	ROR	992	949	165	888	4,667	1,297	2011-15	875.1	2.97
4	Chamkharchu-I	Bumthang	ROR	671	651	113	645	3,207	942	2014-19	546.8	2.97
5	Chamkharchu-II	Bumthang	ROR	568	551	95	546	2,714	797	2018-22	407.0	2.48
6	Kholongchu	Trashi-yangtse	ROR	486	478	61	361	2,207	527	2020-23	382.9	2.64
7	Amorchu	Samtse	ROR	499	487	82	473	2,210	690	5 years	500.9	3.62
Total		-		4,888	4,746	776	4,368	22,684	6,378	-	4,161.70	-

*1: ROR = Run-of-River

*2: Economic Unit Cost of Energy at Delivery Point

(Source : Final Report of PSMP)

(2) Some Changes for Future Hydropower Development Priority from PSMP

Regarding the upgrading of the power generation capacity, the RGoB has discussed the issue of exporting generated hydropower energy from Bhutan through the development of large hydro sites with the Government of India, which is a vast and readily available market. The Indian government showed keen interest in upgrading the generating installed capacity to 10,000 MW instead of 5,000 MW by 2020 and the bilateral agreement for the same has been signed between the two governments.

This is a very ambitious deal to execute requiring intensive study and verification of potential hydro sites for starting the construction. The PSMP development priority sites of such large-scale hydropower stations highlighted in the above Table-2.1.11 needed reconsideration to cater to the revised development plan of 10,000 MW. Accordingly, DOE has carried out studies, modified the development priority list of the ten candidate sites and awarded the study for detailed project report (DPR) preparation. The list of such candidate sites along with their development status/plan and DPR completion schedule is provided in Table-2.1.12. The location of the candidate sites in Bhutan is shown in Figure-2.1.5. The construction of Punatsangchu-I is underway since a year ago with minor shifting of the intake upstream from its original design resulting in the increase of the generating capacity to 1,200 MW. The mobilization for the construction of Punatsangchu-II and Mangdechu projects has also started.

Table-2.1.12 Revised Hydropower Projects under the 10,000 MW Development Plan

SI. No.	Hydroelectric Projects	Installed Capacity (MW)	DPR Completion Schedule	Construction Schedule	Project Cost (Nu./Rs. Million)
1	Punatsangchu-I	1,200	Done	2009-2015	36,348 (as per Final DPR at December 2006 Price Level)
2	Punatsangchu-II	990	Done	2010-2016	37,778 (qas per Final DPR at March 2009 Price Level)
3	Mangdechu	720	Done	2010-2016	28,963 (as per revised estimate of NHPC)
4	Sankosh Reservoir	4,060	September 2010	2011-2020	139,197 (as per THDC's revised estimate)
5	Kuri-Gongri	1,800	December 2011	2012- 2019	79,200*
6	Wangchu	600	December 2011	2012- 2019	33,600*
7	Bunakha Reservoir	180	March 2011	2012- 2018	12,240*
8	Kholongchu	486	June 2011	2012- 2018	25,272*
9	Chamkharchu-I	670	December 2011	2012- 2018	37,520*
10	Amochu Reservoir	620	September 2011	2012- 2018	39,680*

* Cost estimated on per MW Unit Cost

(Source: DOE)

Figure-2.1.5 Location of Hydropower Projects under the 10,000 MW Development Plan

(Source: DOE)

(3) Development of Transmission System

The interconnecting HV transmission lines are for exporting energy from the abovementioned priority candidate power stations to the Indian grid and for domestic supply. Similarly, the related HV substations are for the domestic supply of industrial power. The HV transmission lines and substations will be upgraded/constructed to cater to the needs of evacuating power for export as well as domestic supply according to the upgrading plan of the generating stations. The 400 kV transmission systems are considered for energy export to India.

Figure-2.1.6 outlines the plan of DOE and BPC based on PSMP for the new transmission line facilities to be constructed.

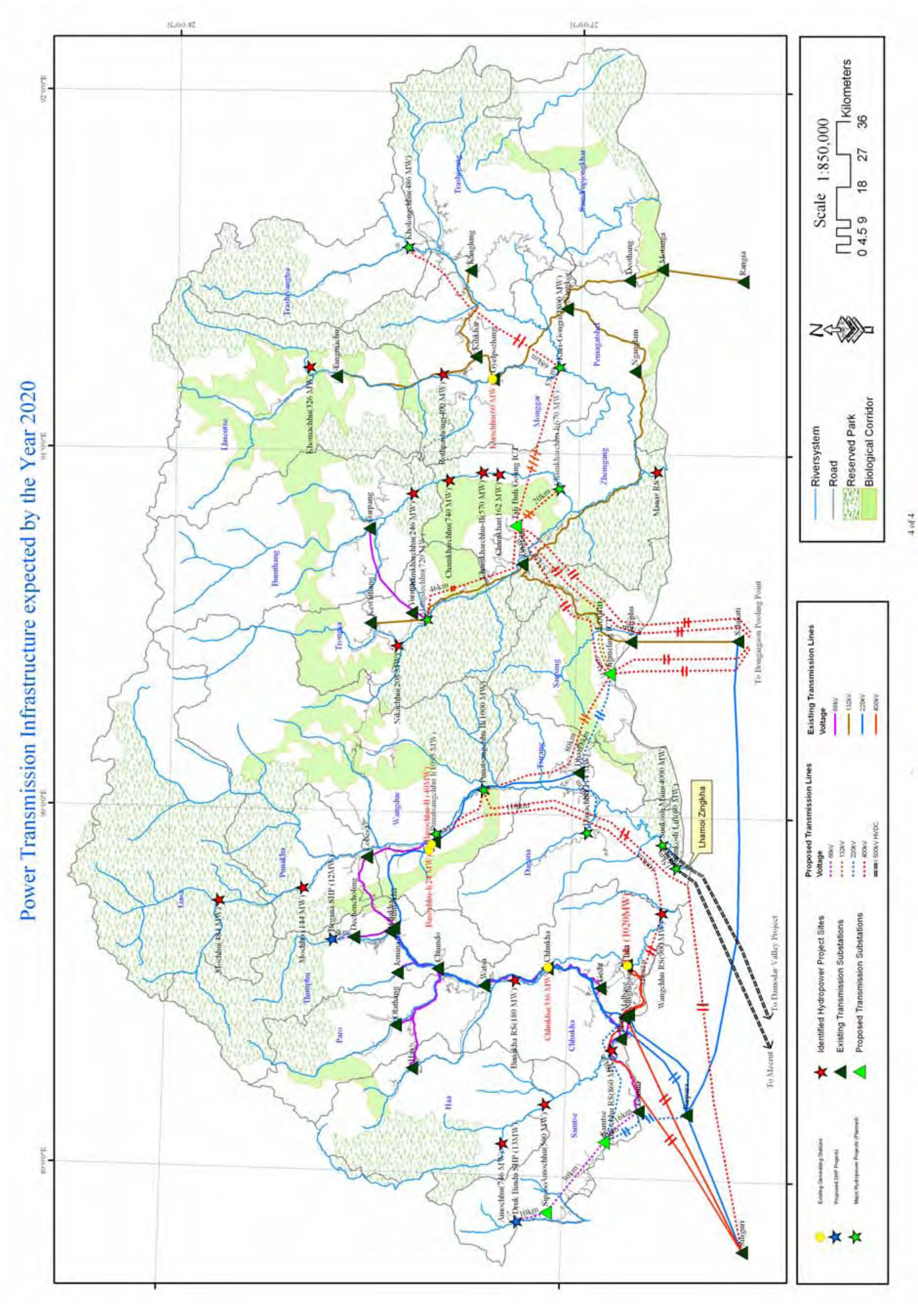


Figure-2.1.6 New Transmission Line Facilities to be Completed by 2020

(Source: BPC)

2.1.5 Rural Electrification Plan

(1) Rural Electrification Master Plan

The RGoB's RE efforts are guided by the *Bhutan 2020: A Vision for Peace, Prosperity and Happiness* document. This document sets a target of providing electricity to all the households by 2020. To meet this target, a Rural Electrification Master Plan (REMP) for Bhutan was prepared in 2005 with support from JICA. JICA formulated village-level RE plans for the 10th, 11th, and 12th five-year plans (FYPs) toward the 2020 target of 100% electrification covering all the 20 dzongkhags. The process followed in the preparation of the REMP is as follows:

1) Identification of non-electrified villages
2) Mapping of existing distribution lines
3) Technical design of new distribution feeders to cover the non-electrified villages
4) Costing of each new feeder
5) Cost-benefit analysis for each feeder
6) If benefit-cost (B/C) ratio is negative: The villages are covered by the feeder included in the off-grid electrification plans, i.e., micro or mini hydro and solar PV
7) If B/C ratio is positive: The villages are covered by the feeder included in the on-grid electrification plans
8) The feeders included in the on-grid electrification are then ranked based on:
    - Economic priority, i.e., an economic internal rate of return (EIRR) of more than 12%;
    - Contribution to equity in the dzongkhag electrification ratio;
    - Access from existing motorable roads; and
    - Development of a phased electrification plan with respect to how many households will be electrified by which feeder and in which FYP.

(2) Optimized On-grid Electrification Plan

There is a need to accelerate the current state of electrification to achieve the targets set by the REMP for the 10th FYP. At present, there is an even more aggressive goal set by the new government for completion of the RE process by 2013. Accordingly, DOE and BPC have been revising the REMP to achieve the new RE completion target of 2013. The on-grid electrification plan to accomplish the new target is being framed by DOE and BPC under the ADB/RE-5 and JICA RE-2 projects as final projects to complete the target on-grid households.

(3) Off-grid Electrification Plan

The REMP identified and forecasted 3,918 and 5,133 households under off-grid villages in 2007 and 2020, respectively. Here, an off-grid system basically represents a solar home system. Mini/micro hydropower for villages with a high power source potential is defined as an optional plan which will only be implemented when grants from donors can be secured. Accordingly, the project cost calculations and economic evaluations in the REMP were based on distribution line extensions for on-grid electrification and solar home systems for off-grid electrification. Project costs for mini/micro hydropower systems were not included in the implementation cost that was estimated in REMP.

According to DOE policy, the target number of off-grid electrification households was planned to be 2,000 for the 10th FYP and the remaining target off-grid households were planned to be electrified in the 11th FYP. But now, with the new target set by the government for full completion of RE by 2013, the DOE has been rescheduling aggressively for meeting the government’s new target date of completion for all off-grid electrification.

2.2 Past Rural Electrification Project

2.2.1 Outline

The RGoB places a high priority on RE from the viewpoints of equalizing urban and rural divergence, poverty reduction, and promotion of industrial development. In total, 12,717 households had been electrified up to the 6th FYP (before 1992). In the 7th FYP (1992 to 1997), 5,778 households were electrified. In the 8th FYP (1997 to 2002), 9,778 households were electrified. A total of 16,418 households were electrified during 9th FYP (2002-2007-08). The REMP was also formulated during this FYP in 2005 with funding from JICA.

The resources and funding available for the 7th and 8th FYPs were mainly from ADB and the RGoB. In the 9th FYP, other donors like the Sustainable Development Secretariat (SDS, Netherlands) and Austrian Coordination Bureau (ACB) also provided support for RE in addition to the funding from ADB. Further, the Japanese government showed keen interest in the RE process of the RGoB during this period and offered JICA funding for the formulation of the Dzongkhag-wise REMP as well as conducted the JBIC Special Assistance for Project Formation (SAPROF) Study based on the result of the REMP for RE project finalization. Accordingly, the JBIC SAPROF report was finalized in 2006 and the project is currently under implementation since 2008 to electrify about 15,451 households.

Currently, RE in Bhutan has been implemented mainly through ADB and JICA soft loan-funded projects.

2.2.2 ADB Rural Electrification Project

The ADB already completed three projects and there are two ongoing projects, namely, ADB RE-4 and JICA RE-1 as follows:

1) ADB/RE-1: The project was planned during the 7th FYP (1992 to 1997), completed in June 2000, and electrified about 3,123 households.

2) ADB/RE-2: The project was planned during the 8th FYP (1997 to 2002), completed in December 2003, and electrified about 8,910 households in 150 villages.
3) ADB/RE-3: The project was implemented from 2003 to 2007 and electrified about 9,206 households.
4) ADB/RE-4: The project is currently in the implementation stage since 2008 and is expected to electrify about 8,767 households in nine dzongkhags (Lhuentse, Pemagatshel, Samdrup Jongkhar, Punakha, Sarpang, Trashigang, Wangduephodrang, Mongar and Dagana).

2.2.3 JICA RE-1 Rural Electrification Project

The JICA RE-1 (also known as JBIC SAPROF) Rural Electrification Project is being implemented since 2008 by BPC for the electrification of about 15,712 households covering 547 villages in ten dzongkhags, namely: Bumthang, Chukha, Dagana, Haa, Mongar, Paro, Samtse, Trashiyangtse, Trongsa and Tsirang. The project is expected to be completed by mid-2011.

The JICA project's scope for RE was set to be:

i) Expansion of 33 kV/11 kV distribution lines in 10 dzongkhags (15,451 households, 77 feeders, and 924 km line) and necessary upgrading of existing lines; and
ii) Construction of LV lines and service wiring to consumers.

The validity of the above scope was assessed in terms of needs, capacity of the implementing/executing agency, funding availability, and project scale. Outline of the JICA RE-1 project is as follows:

1)	Target dzongkags	10
2)	Target villages	547
3)	Households*	15,451
4)	Service connections*	16,810
5)	Feeders	77
6)	MV line length	924 km
7)	LV line length	1,488 km
8)	Project cost	US$ 38,715,000

*Numbers of households and service connections applies the numbers in 2007, when 10th FYP started.

The total cost for the project is US$38.7 million and the breakdown is shown in Table-2.2.1.

Table-2.2.1 Total Cost of JICA RE-1 Rural Electrification Project

No.	Items	Cost (x US$1,000)	
		Local	Foreign
A	Construction Cost of Distribution Lines (Materials)		18,631
B	Construction Cost of Distribution Lines (Transportation & Erection)	13,402	
C	Administration (8% of A+B)	2,563	
D	Contingency (5% of A+B)	670	932
E	Consultancy Service		1,778
F	Capacity Building		740
	Total Cost	16,635	22,080
	Total Project Cost	38,715	
	Percentage	43.0%	57.0%

(Source: JBIC SAPROF 2006 Report)

2.3 Activities of Donors in Power Sector

The donor projects in the power sector in Bhutan are listed below.

2.3.1 Hydropower

Table-2.3.1 Donor Activities for Hydro Power

Project	Commission Year	Cost of Completion (Nu. in million)	Financing Terms	Existing Tariff (Nu. per kWh)	Power Export Agreement
Chukha (336 MW)	1986-88	2,460 excluding IDC 1,554.73 million	Govt. of India financing (60% grant and 40% loan with 5% interest with 15 years repayment tenure)	2.00 (to be reviewed as per mutual consent of the two govts)	PPA with Power Trading Corporation (agreement to be renewed after 2017)
Kurichu (60 MW)	2001-02	5,640 excluding IDC 975 million	Govt. of India financing (60% grant and 40% loan with 10.75% interest with 15 years repayment tenure)	1.8 (tariff to be reviewed every four years)	PPA with Power Trading Corporation (agreement to be renewed after 2027)
Basochu – I (24 MW)	2001	1,422	Austrian Govt. with interest free loan with 20 years repayment tenure	1.2	Bulk sales to Chukha
Basochu – II (40 MW)	2004	1,700	90.75 funded by Austrian Govt. with 2.786% interest with 15 years repayment tenure	1.2	Bulk sales to Chukha
Tala (1020 MW)	2006-07	41,850 excluding IDC 7,263 million	Govt. of India financing (60% grant and 40% loan with 9% interest with 12 years repayment tenure)	1.8 (tariff to be escalated at 10% every five years till repayment of debt and thereafter increase by 5% every five years	PPA with Power Trading Corporation (agreement to be renewed after 35 years w.e.f. 2006)

(Source: DOE)

2.3.2 Transmission Lines and Substations

Table-2.3.2 Donor Activities for Transmission Lines and Substations

Donor	Project Title	Type	Period	Amount million US$	Consultant
Government of India	DPR of Punatshangchu Phase I	Grant	2003-2006	3.333	
	400kV Double Circuit Punatsangchu-I TL (2 nos. of line)	Grant & Loan	2010-2014	172.440	POWERGRID
	Integrated Energy Management Master Plan	Grant	2005-2007	2.222	TERI
	Tingtibi-Yurmoo-Bumthang 132k V transmission line	Grant	2006-2008	8.444	CEA
	Deothang-Rangia Transmission Line	Grant	2006-2008	5.078	POWERGRID

Source:BPC

2.3.3 Rural Electrification

The donor projects in the power sector for RE in Bhutan are listed in Table-2.3.3 for the on-grid projects and Table-2.3.4 for the off-grid projects.

(1) On-grid Project

Table-2.3.3 Donor Activities for On-grid Rural Electrification

Funding Agency	Project	Start	End	Amount ($ million)	Type	Electrified Households	Cumulative Electrified Households	Electrification Ratio (Total No. of HHs: 87,804*1)
India	Rural Electrification	1993	1999	1.108	GRANT	700	22,308	25.4%
ADB	Rural Electrification-I	1995	1999	7.5	LOAN	3,123	25,431	29.0%
SDS	Rural Electrification-I	1995	1999	1.373	GRANT	514	25,945	29.5%
ADB	Sustainable Rural Electrification- II	1997	2002	10	LOAN	8,190	34,135	38.9%
Gov. of Austria	Rural Electrification Phase-1	2001	2002	0.289	GRANT	228	34,363	39.1%
Gov. of Austria	Rural Electrification Phase-2	2002	2003	0.511	GRANT	266	34,629	39.4%
Gov. of Austria	Rural Electrification Phase-3	2003	2004	0.511	GRANT	511	35,140	40.0%
Gov. of Austria	Rural Electrification Phase-4	2004	2005	0.678	GRANT	509	35,649	40.6%
SDS	Rural Electrification-II	2002	2007	6.689	GRANT	4,105	39,754	45.3%
ADB	Rural Electrification and Network Expansion- III	2003	2007	9.4	LOAN	9,206	48,960	55.8%
Gov. of Austria	Rural Electrification Phase-5	2006	2009	0.275	GRANT	109	49,069	55.9%
SDS	Rural Electrification-III	2008	2009	0.1	GRANT	28	49,097	55.9%
Gov. of Austria	Rural Electrification Phase-6	2008	2011	Euro 1.6 mil.	GRANT	800	49,897	56.8%
JICA	JICA RE-I	2008	2011	Yen 3.576 bil.	LOAN	15,712	65,609	74.7%

ADB	Preparing the Bhutan Power Development Project RE-IV	2009	2011	25.28	GRANT	8,767	74,376	84.7%
ADB	ADB RE-5	2010	2013	15.49	GRANT	5,075	79,451	90.5%
JICA	JICA RE-2	2010	2013	24.93	LOAN	3,701	83,152	100%*2 (94.7%)*3

*1: Data in 2005, source: Final Report of Rural Electrification and Transmission, TA 4916 BHU: Preparing the Bhutan Power Development Project, January 2009, *2: Including the HHs electrified by BPC own fund and off-grid, *3: Including on-grid electrified HHs only.

(Source: DOE)

(2) Off-grid Project

Table 2.3.4 Donor Activity for Off-grid Rural Electrification

Year of implementation	No. of sets	Total expenditure (Nu.)	Donors/type of support
2001-2002	1,249	34,195,879.0	SDS/Grant
2001-2002	51	1,204,473.0	Funded by Ecooperation of the Netherlands/Grant
2008-09	505	N/A	JFPR
2009-10	52	N/A	Under improvement of rural power supply/JICA
2008-2009	200	N/A	Implemented by Tarayana under SGP
2010-2013	1,850	USD 144,900	ADB

(Source: DOE, ADB PPTA Study Team)

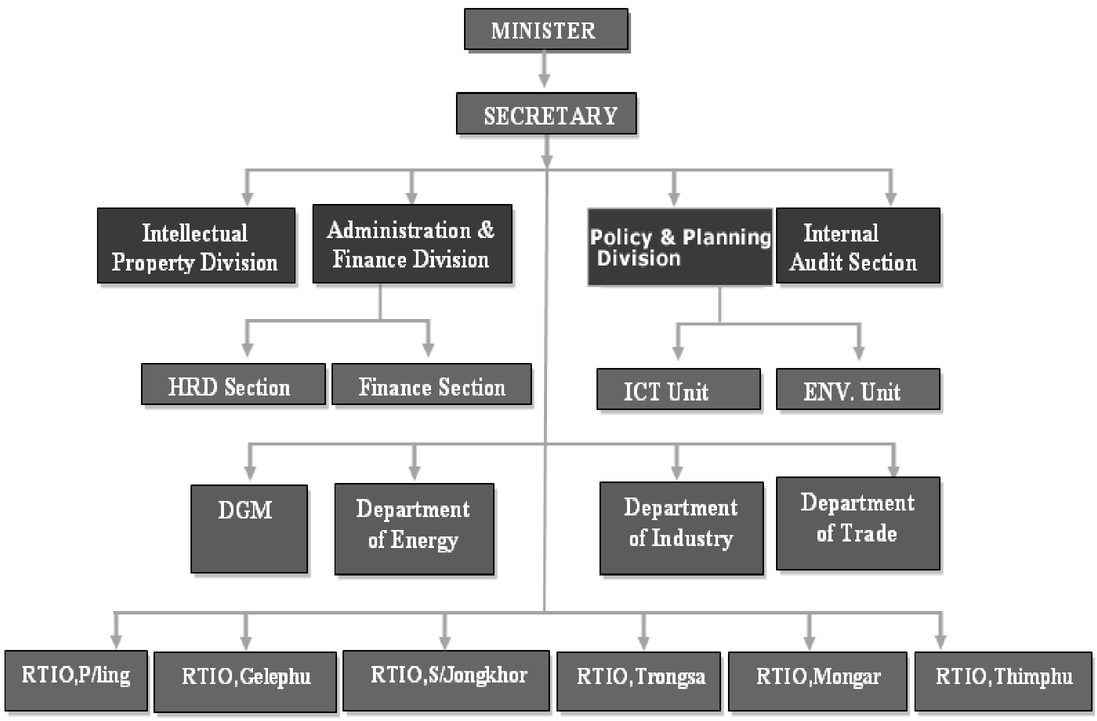
CHAPTER 3 NEEDS FOR THE PROJECT

3.1 Evaluation of Executing/Implementing Agency's Capacity

3.1.1 Current Institutional Setup

(1) Energy Sector

The power/energy sector of Bhutan is generally administered by the Ministry of Economic Affairs (MOEA). MOEA comprises of four technical departments, namely: the Departments of Trade, Industry, Energy (DOE) and Geology and Mines (DGM) besides the four service divisions, namely: Policy and Planning, Administration and Finance, Human Resource and Intellectual Property. MOEA also has an Internal Audit Unit and six Regional Trade Offices in Thimphu, Phuntsholing, Gelephu, Trongsa, Mongar and Samdrup Jongkhar. Figure-3.1.1 below shows the organogram of MOEA.

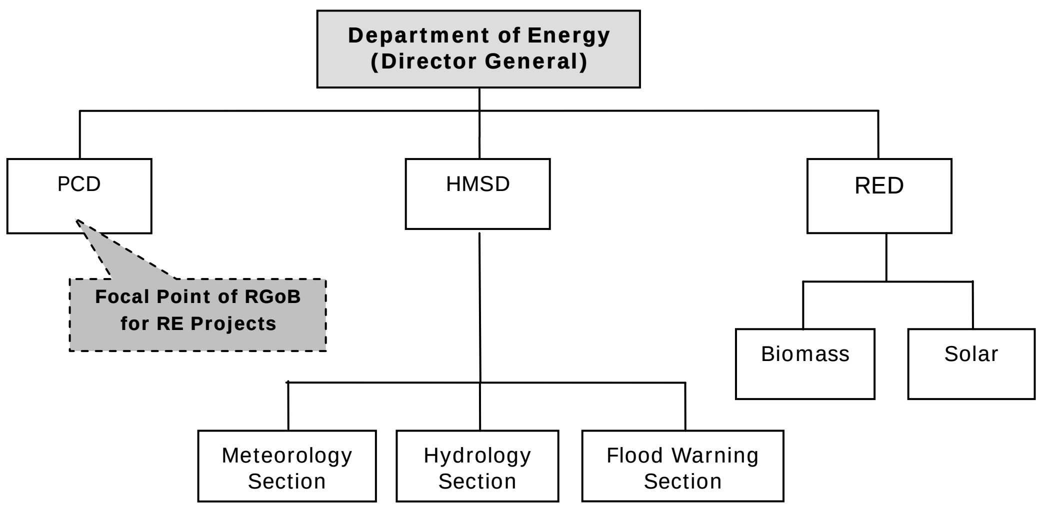


Source: MOEA website, http://www.moea.gov.bt/pages/aboutministry.php

Figure-3.1.1 Organization of MOEA

The main entities under the MOEA operating within the power/energy sector are the DOE, Bhutan Electricity Authority (BEA), and the utility companies – Druk Green Power Corporation (DGPC) and Bhutan Power Corporation (BPC). BEA is an autonomous regulatory body for regulation of the power sector as per Electricity Act, 2001. It is authorized to develop standards and codes for generation, transmission and distribution of electricity. Also, it formulates and approves tariffs. BEA is further responsible for licensing and monitoring functions, and preparing resolutions related to the power sector. The utility company, DGPC, is mandated to look after existing power generating facilities for operation and maintenance (O&M) and takes a lead role to accelerate the hydropower development in the country. On the other hand, the public utility service company, BPC, is responsible for transmission, distribution, and supply of electricity across the country besides operating small, mini and micro hydropower plants. In the present institutional setup, the two major players for execution/implementation of rural electrification (RE) projects are DOE and BPC. DOE is responsible for project planning and design, after which BPC takes up the implementation and O&M. The power regulations, standards and codes approved by BEA are followed for the implementation and O&M of RE projects.

The DOE under the MOEA, which was formed in 2002 during the restructuring of the erstwhile Department of Power, is a central government agency responsible for the formulation of policies, plans, programs, and guidelines/regulations related to the energy and power sector including renewable energy. It also provides technical advice to Royal Government of Bhutan (RGoB) on all aspects related to energy, including development strategy, monitoring and evaluation of the implementation plans, and initiating and maintaining programs and schedules. DOE also performs the function of RGoB/donor/lender fund coordination related to energy/power sector projects. It is also responsible for giving techno-economic clearances and technical sanctions for all capital works in the energy/power sector. DOE currently has three divisions with nearly 200 employees, and it is headed by a Director General. Figure-3.1.2 below shows the organogram of DOE and Table 3.1.1 shows its present manpower strength.



PCD: Planning and Coordination Division; HMSD: Hydro-Meteorology Services Division
RED: Renewable Energy Division

Figure-3.1.2 Organization of the Department of Energy

The Planning and Coordination Division (PCD) is the focal point of RE projects during the planning, design and approval stages. Further, PCD also formulates plans and prepares projects and program documents for the development of large, small, mini and micro hydropower projects. It carries out coordination for expansion and upgrading of power systems including system analysis.

The Hydromet Services Division (HMSD) plans, designs, operates and maintains hydro-meteorological network throughout the country, disseminates data to the end users, and provides early warning related to hydro-meteorological hazards including the glacial lake outburst flood (GLOF) early warning.

The Renewable Energy Division (RED) of DOE is a government promotion channel for renewable energy within the country. It is mandated to develop and promote all modern forms of renewable energy resources/technologies, manpower development including energy conservation and efficiency improvement measures. The current focus of DOE-RED is mainly in solar energy program, biomass programme, energy conservation and efficiency improvement program and institutional capacity development related to renewable energy. As a future activity of RED, it is required to develop the relevant renewable energy policy and legal framework for electrification with renewable energies.

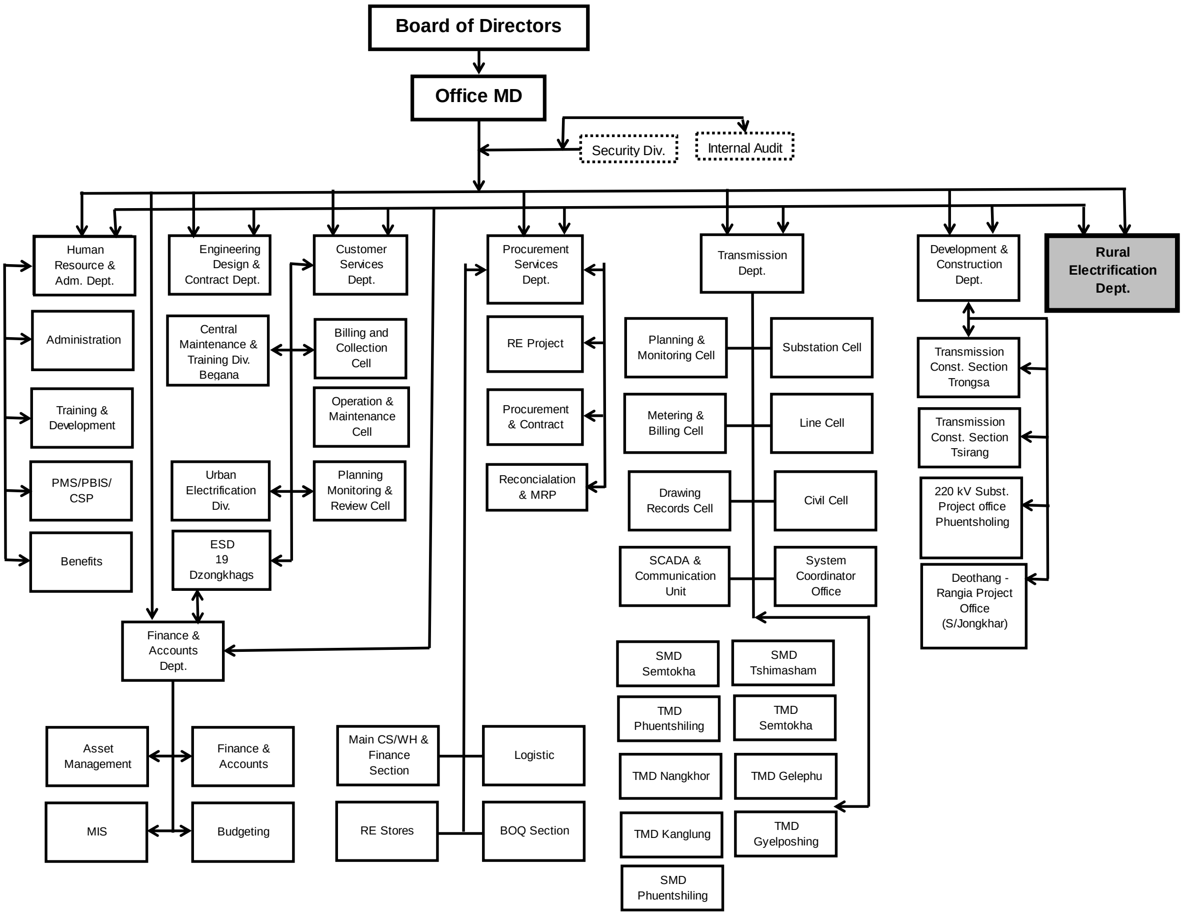
Table-3.1.1 DOE Staffing

Department	Manpower
Planning & Coordination Division (PCD)	23
Hydromet Service Division (HMSD)	142
Renewable Energy Division (RED)	23
Directorate	4
Total	192

Source : DOE

(2) BPC

BPC is a utility corporation governed by a board of seven directors and is headed by a Managing Director. It has eight departments, namely: Human Resource and Administration, Finance and Accounts, Engineering Department and Contract, Distribution and Construction Services, Procurement Services, Transmission, Development and Construction, and Rural Electrification. Moreover, the **Managing Director's office** also consists of Corporate Planning and Business Development Unit, Internal Audit, Legal Compliance, Planning and Coordination Cell, and System Inspection and Safety Compliance Division. The field offices of BPC are spread out in all 20 dzongkhags (districts). The present organogram of BPC is shown in Figure-3.1.3.



Source: BPC

Figure-3.1.3 Organization of Bhutan Power Corporation

The manpower distribution of BPC is as shown in the following Table-3.1.2.

Table-3.1.2 BPC Staffing

Department	Manpower
MD's office	14
Humnan Resources & Administration	29
Finance and Accounts	58
Engineering Design & Contract Department (EDCD)	52
Distribution and Customer Services Department (DCSD)	826
Procurement Services Department (PSD)	84
Transmission Department (TD)	558
Development and Construction Department (DCD)	121
Rural Electrifcation Department (RED)	163
Security Service	27
Total	1932

Source: BPC

The Human Resource and Administration Department of BPC functions in the interest of the corporation for capacity building, as and when required, of highly motivated employees with engineering, accounting, finance, and other academic backgrounds. It also initiates manpower recruitment for BPC.

The endeavor of the **Finance and Accounts Department** is to make the corporation a self-sustainable and profitable entity. Therefore, optimal and efficient use of resources, appropriate management control system, relevant budgeting mechanisms, and proper check and balance in the internal system are the important job aspects of the department. The department is further entrusted with the management of the corporate funds and assets in an efficient and effective manner. At the operational level, the department is mandated to ensure transparency in all its financial dealings, be accountable for all its financial transactions, and build professionalism and team sprit for efficient and effective operation.

The main task of **Engineering, Design Contract Department (EDCD)** is to "provide in-house technical and engineering expertise keeping in pace with the state-of-the-art technology and seamless and integrated computer system". One of the main functions of EDCD is to streamline the multitude of expertise and experience, and develop standard designs / procedures that can be followed uniformly by all the departments of BPC.

The main mission of the **Distribution and Customer Services Department (DCSD)** is to provide affordable, adequate, safe, reliable and good quality power supply to all the customers of the country. The field offices of DCSD are available throughout the country in the form of Electricity Services Division (ESD) in the dzongkhag headquarters and Electricity Services Sub-Division (ESSD) in dungkhags (subdistricts), towns and other areas.

The **Procurement Services Department (PSD)** handles all procurement of goods, services, warehousing, logistics and related works. In addition, cross-functional teams are established especially in the technical areas in order to handle ambiguous requisitions, propose standardizations, and provide technical support and to maintain overall transparency in the procurement procedures. They have three regional stores located at Phuentsholing, Samdrup Jongkhar and Gelephu. These stores of PSD serve as materials and equipment storage and dispatch centers for construction sites. The locations of regional and micro stores and the route of the transportation of materials from regional stores to construction sites are as shown in Figure-3.1.4.

The **Transmission Department (TD)** is mandated to ensure uninterrupted availability of transmission network for evacuation of electricity to domestic and export markets. It is responsible for evacuating power from various generating stations to load centers and provides link for export of power to India, through transmission networks (transmission lines and high voltage substations) of 66 kV and above. Its field offices, equipped for O&M of high voltage transmission lines and substation, are established at different locations in the form of Transmission Maintenance Division (TMD) and Substation Maintenance Division (SMD) at Semtokha, Tshimasham (Chukha), Phuentsholing, Nangkhor, Gelephu, Kanglung, and Gyelposhing.

The **Development and Construction Department (D&CD)** is responsible for implementation/ execution of major power transmission, sub-transmission and infrastructure development. Currently, the department consists of the following offices:

i) *400 kV Punatsangchu – I Transmission Project Office at Lobeysa* - The project office, headed by a superintending engineer with three divisions at Kamichu in Wangdue, Dagapela and Lhamoizingkha in Dagana, is responsible for the execution and implementation of the Punatsangchu – I Transmission System (covering 110 km of Punatsangchu I – Monitar) and 100 km of Punatsangchu I – Lhamoizingkha 400 kV D/C lines for evacuation of power from Punatsangchu-I Hydro Electric Project to India.

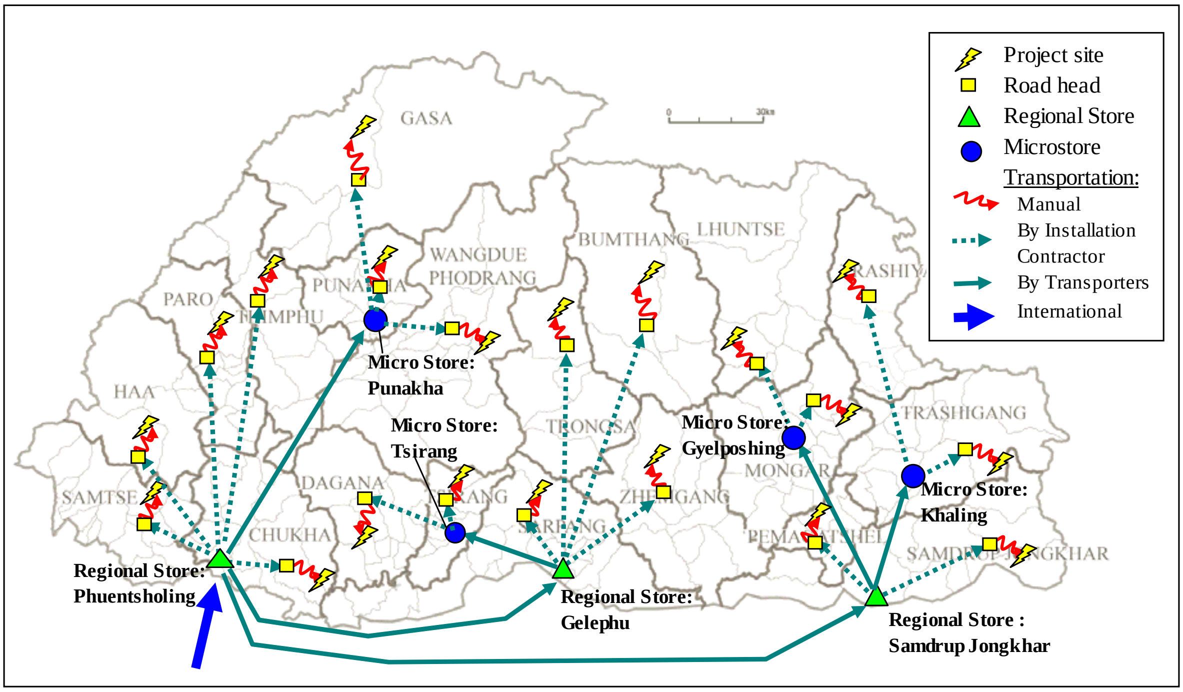
ii) *220 kV Dagachu – Tsirang – Jigmeling – Lodrai Transmission Project Office, Tsirang* - The project office, headed by a superintending engineer (projects) with two divisions at Tsirang and Jigmeling in Glephu, is responsible for the construction of about 60 km of 220 kV D/C Dagachu – Tsirang – Jigmeling – Lodrai transmission line with associated 220/66 kV and 220/132/33 kV substations at Tsirang and Jigmeling, respectively.

iii) *Transmission Construction Section – Central, Trongsa* - This office, headed by a Project Manager, is implementing the construction of 132 kV Tintibi – Yurmoo; 66 kV Yurmoo – Trongsa and 66 kV Yurmoo – Bumthang S/C transmission lines. With the Tintibi – Yurmoo – Trongsa line having already completed and charged at 33 kV since October, 2008, the grid power is extended from Kurichu Hydropower Plant to serve the people of Trongsa, and further to Bumthang (through existing 11 kV line) who were earlier fed through restricted supply from Chumey Mini Hydro.

iv) *Deothang – Rangia Project Office, Samdrup Jongkhar* - This office, headed by a project manager, had successfully commissioned the 132 kV S/C transmission line from Deothang – Rangia in India along with bay extensions at Deothang and Rangia substations. Presently, this office is executing the construction of a 132 kV Lilo Substation at Motanga and the 132 kV S/C transmission line at Nganglam, Pemagatshel to supply power to Dungsam Cement Factory.

The Rural Electrification Department (RED) is responsible for construction of medium voltage (MV) and low voltage (LV) electricity distribution infrastructure by grid extension and ultimately providing service connections to rural areas. The RGoB aims to provide "Electricity for All by 2013". In order to achieve this target, BPC has been entrusted with the responsibility of providing electricity service connections to over 40,000 rural households during the 10th FYP period.

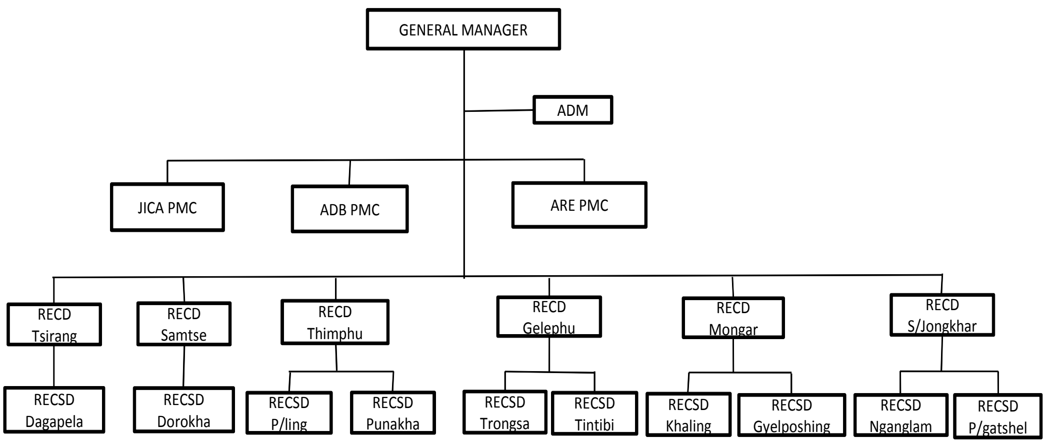
Once an RE project is provided techno-economics clearance from DOE, it is handed over to BPC for further implementation. The tendering and procurement of on-grid RE materials and equipment are carried out by PSD while the actual field construction of the RE distribution network is undertaken by RED. After construction and commissioning of the project, RED hands over the newly installed power supply network to the concerned ESD for onward O&M.



Source : BPC

Figure-3.1.4 The locations of regional/micro stores and the route of transportation of material

In the current institutional setup, RED has three project management cells at the headquarters in Thimphu which manage the three RE projects, viz. JICA loan project, ADB loan project and the Accelerated Rural Electrification project. Besides, there are six Rural Electrification Construction Divisions (RECDs) and ten Rural Electrification Construction Sub-divisions (RECSDs) established around the country to supervise and monitor all RE works. For effective dispensing of materials and equipment, four RE micro stores are maintained with RECDs at Khaling, Gyelposhing, Punakha and Tsirang. Figure-3.1.5 shows the existing organogram of RED.



Source : BPC

Figure-3.1.5 Organization of RED

The construction supervision and monitoring by RED cover MV and LV distribution infrastructure by grid extensions and ultimately providing service connections to the rural households.

RED now has a total strength of 163 staff (see Table-3.1.3) of which 24 are engineers/managers, 74 are line technicians/supervisors and 65 are field helpers and support staff.

Table-3.1.3 RED Staffing

Department/Division	Manager/Engineer	Supervisor/Technician	Helpers/Driver	Total
RED, Thimphu	7	5	3	15
RECD, Thimphu	2	1	4	7
RECSD, P/ling	1	3	3	7
RECSD, Punakha		6	3	9
RECD, Tsirang	2	12	11	25
RECSD, Dagapela	1	2		3
RECD, Mongar	2	6	11	19
RECSD, Khaling	1	4	1	6
RECSD, Gyelposhing		6		6
RECD, S/jongkhar	1	8	8	17
RECSD, Pemagatshel	1	2		3
RECSD, Nganglam		2		2
RECD, Gelephu	2	4	10	16
RECSD, Trongsa/Tintibi	2	4	3	9
RECD, Samtse/Dorokha	2	9	8	19
Total	24	74	65	163

Source : BPC

3.1.2 Electricity Tariff System

The tariff levied by BPC to the customers is in line with the electricity tariff approved by BEA from time to time.

3.2 Present Status of Data Management by GIS

3.2.1 Human Resources

(1) BPC

BPC GIS personnel consists of one person from the Rural Electrification Department (RED) and another person from the Engineering Design and Contract Department (EDCD). The RED GIS person is in charge of the management of the GIS data for distribution line facilities. The EDCD GIS person is in charge of the management of GIS data for all power supply facilities including power plants, transmission and distribution facilities.

(2) DOE

DOE GIS personnel consists of two persons from the Planning and Coordination Division (PCD). DOE GIS personnel is in charge of the management of GIS data for all power supply facilities including power plants, transmission and distribution facilities. The GIS data is provided by BPC after updating.

3.2.2 Software and Equipment

(1) BPC

Software: ArcGIS 9.2 by ESRI, with extensions of 3D Analyst, Spatial Analyst, Network Analyst, Schematics, etc. (Number of licenses: ArcInfo – 1, ArcEditor – 1, ArcView – 1)

Equipment: GPS receiver – 27 units by Garmin

(2) DOE

Software: ArcGIS 9.1 by ESRI (Number of licenses: ArcEditor – 3 floating licenses) with extensions of Spatial Analyst and 3D Analyst

Equipment: GPS receiver – None

3.2.3 Data Management in Distribution Line Planning

(1) Updating Procedure of the GIS Data

The GIS data of the newly constructed distribution lines is updated according to the following procedure:

1) DOE and BPC headquarter (HQ) study the route of the proposed distribution lines based on the existing GIS map.
2) The location of the proposed distribution line route is surveyed with GPS receivers at the site. BPC division offices, namely, Rural Electrification Construction Division (RECD) located in six regions and Rural Electrification Construction Sub-division (RE-CSD) in seven regions, conduct the site survey.
3) RECD and RE-CSD send the global positioning system (GPS) and computer-aided design (CAD) data of the surveyed route to the RED GIS person in BPC HQ via e-mail, or the site surveyor brings the data to RED office.
4) RED GIS person converts the GPS data to GIS data, adds it to the existing GIS map, and makes the bill of quantity using GPS data.

Communication between the HQ and division offices is mainly through telephone. The internet is available in Samtse, Mongar and Gelephu division offices, but only small files such as simple excel files can be sent by e-mail due to the poor line condition. In case large files such as CAD will be sent or data will come from the division offices where internet is not available, the site surveyor brings the soft and hard copies of the survey result to the HQ office.

(2) GIS Data Storage and Utilization in DOE

The updated GIS map in BPC is shared with DOE. DOE utilizes the GIS for the future construction plan of distribution line.

(3) Problems in Present GIS Data Management

The following issues are pointed out as problems in the present GIS data management based on the interviews with GIS personnel in BPC HQ:

- ✓ Difficulty to secure consistency of the data (e.g., feeder ID and field name of attribute data is not named according to standardized rules).
- ✓ Lack of opportunity to obtain advanced skills. The GIS management skill remains as it was in 2003 when GIS was first introduced.
- ✓ Absence of experts whom GIS persons can consult about troubles or how to start new activities.
- ✓ Few opportunities to see actual examples of the application of GIS.
- ✓ Lack of funds to purchase additional GIS software licenses though BPC is planning to increase GIS persons.
- ✓ Inefficient data exchange between HQ and division offices due to poor internet condition.

The following issues are pointed out as problems in the present GIS data management based on the interview with the GIS personnel in DOE:

- ✓ No special problems in manipulating GIS software.
- ✓ On the other hand, there are several problems in the GIS data management. For example, it is sometimes difficult to specify the latest and correct GIS data since both DOE and BPC separately add modifications to the GIS data.
- ✓ It is difficult to standardize the data format and procedure of updating the GIS data since the objectives of the utilization of GIS data depend on the projects and users of the GIS data.

3.2.4 Future Plan

The following is the GIS enhancement plan of BPC in the near future:

- ✓ Additional two GIS persons in EDCD
- ✓ Additional GIS person in the other department of BPC HQ is planned. RED and EDCD GIS persons conducted training courses for seven persons from RED and 28 persons from Customer Service Department (CSD). The schedule and content of the trainings are shown in Table-3.2.1.

Table-3.2.1 Summary of the GIS Training Course

When	Duration	Participant	Contents of training course
March, 2009	1 week	7 people from RED	Basic GIS concept, Basic use of GPS receiver, Basic use of ArcGIS
July, 2010	2 weeks	28 people from CSD	Basic GIS concept, Basic use of GPS receiver, Practical GPS survey, Basic use of ArcGIS and its extensions, etc.

Source: BPC EDCD

- ✓ BPC is willing to expand the application of GIS not only for information on power facilities but also for customers or environment in the future.

DOE has:

- ✓ No plan for additional GIS staff.
- ✓ Willingness to expand the GIS database to include the geographical distribution of renewable energy resources in cooperation with other departments.

3.2.5 Assistance Needs

The following assistances are requested by the GIS personnel in BPC and DOE:

- ✓ Purchase of additional licenses and update of GIS software;
- ✓ Training for improving skills on GIS management;
- ✓ Dispatch of experts for consultation;
- ✓ Improvement of internet environment in the division offices; and
- ✓ Training of persons in other departments to improve understanding and manipulating skills of persons other than GIS specialists.

3.3 Current Rural Electrification Implementation

3.3.1 Rural Electrification Program

The RE projects being implemented currently by RED are the following:

i) JICA RE-1 Phase 1 in 9 dzongkhags to connect 10,927 households,

ii) ADB RE-4 Phase 1 in 8 dzongkhags to connect 6,584 households,

iii) JICA RE-1 Phase 2 in 5 dzongkhags to connect 4,785 households, and

iv) ADB RE-4 Phase 2 in 5 dzongkhags to connect 2,183 households.

Table-3.3.1 gives the dzongkhag-wise target households of the current RE projects implemented by RED.

Table-3.3.1 Abstract of Target Households for JICA RE-1 and ADB RE-4 Projects

Sl. No.	Dzongkhag	No. of Target Households			
		JICA RE-1		ADB RE-4	
		Phase 1	Phase 2	Phase 1	Phase 2
1	Bumthang	591			
2	Chukha	465	928		
3	Dagana	2,044	841	510	
4	Gasa				
5	Haa		148		
6	Lhuntse			910	422
7	Mongar	1,007			157
8	Paro	17			
9	Pemagatshel			1,064	534
10	Punakha			215	
11	Samdrupjongkhar			1,871	
12	Samtse	2,243	1,755		
13	Sarpang			794	
14	Thimphu				
15	Trashigang			883	628
16	Trashiyangtse	847			
17	Trongsa	1,142			
18	Tsirang	2,571	1,113		
19	Wangduephodrang			337	442
20	Zhemgang				
Total		**10,927**	**4,785**	**6,584**	**2,183**

Source : BPC

Besides, the Urban Electrification Division of DCSD is implementing an RE project for the electrification of Phobjikha Valley which is jointly funded by Austrian Coordination Bureau and BPC. Under this project, 800 households will be connected to the grid.

Grid connection to certain households or village pockets that have emerged within the electrified areas after completion of previous RE projects are also being extended by ESDs under “RE Fill-In Program” funded by BPC itself.

3.3.2 Planning

Once an RE project is provided with techno-economics clearance from DOE, it is handed over to BPC for further implementation. Detailed route alignment survey with GPS is conducted by RED in order to confirm the material requirement and to seek environmental/forestry clearance, community clearance and public consensus. Bill of material and requirement schedule is prepared and submitted to PSD for procurement and timely delivery of materials.

For the last RE package, BPC has volunteered to do the entire planning cycle from the route survey to implementation, in-house. Thus, some 18 teams to cover all the dzongkhags were deployed to conduct the walk-in survey, followed by detailed route designing. The survey was conducted with GPS with special remarks on pole locations and substations. The route was designed with particular attention to actual implementation.

3.3.3 Procurement

Based on the above detailed line planning, the quantities and costs are tabulated for each dzongkhag on a standardized excel format for each type of conductors, substations, etc., then aggregated for each dzongkhag. Since survey and planning are based on the quantities of feeders and transformer capacities, the costs are derived according to such planning parameters. Quantities for each dzongkhag are reaggregated based on vender specific quantities for the entire project so as to generate bill of quantities (BOQ) for tender packages.

PSD (Procurement Services Department) of BPC sources the construction materials (not by feeder lot but by equipment type such as steel poles and conductors) from manufacturers directly to save costs. Such manufacturers are mostly Indian and Chinese. In accordance with ADB procurement guideline, purchase amounts larger than US$0.5 million should be conducted through international competitive bidding and local currency arrangement, while amounts less than US$0.5 million should be undertaken through a system called international shopping. PSD is fully responsible for these activities including delivery and transport of materials to regional stores as well as to RE micro stores from the port of imports, Phuentsholing. There are three regional stores located at Phuentsholing, Gelephu and Samdrup Jongkhar and four RE micro stores at Khaling, Gyelposhing, Punakha and Tsirang that supply materials to nearby feeder constructions.

Procurement of local contractors for implementing civil works in the field is done by RED through local competitive bidding.

3.3.4 Construction

Construction monitoring is conducted under a standard format, e.g., the 2010 March format shown in Table-3.3.2 for each contract basis. The construction is divided into four components, namely: MV lines, LV lines, substations, and service connections. Each component is sequenced in that order with some overlaps to minimize mismatches in connectivity as clearly visible in the sample. Each component is further divided into subcomponents such as surveys, erection of poles, etc., to further trace the work progress in detail. The system was established during the RE Package III by ADB to monitor the progress of each component. The progress is compiled for each dzongkhag and aggregated into national basis.

Table-3.3.2 Construction Monitoring Sheet

JICA RE PROJECT-LOAN NO. BT-P1
PROGRESS REPORT AS OF MARCH,2010

Sl#	Activities	Unit	Plan	Actual	Progress	%age	Progress Weitage	Weightage Allocated
A	**MV lines**							
1	Survey and Jungle clearing	km	694.075	659.029	614.854	93.297	2.80	**3**
2	Digging of holes for MV Poles	no	14039.70	13556.100	10266.000	75.730	3.79	**5**
3	Digging of holes for stays	no	9126.508	8698.300	3004.000	34.535	1.04	**3**
4	Transportation of MV Poles & Fittings	no	14039.000	13556.100	10296.000	75.951	3.80	**5**
5	Erection of MV Poles	no	14009.000	13528.100	7413.000	54.797	2.74	**5**
6	Erection of stays	set	9126.020	8680.340	1387.000	15.979	0.48	**3**
7	Erection of MV Fittings	no	12793.800	12287.800	4472.000	36.394	1.46	**4**
8	Transportation of Conductors	km	2145.396	2102.387	600.950	28.584	1.43	**5**
9	Stringing of Conductors	km	1465.006	1301.161	41.139	3.162	0.16	**5**
10	Spike Earthing	no	12793.800	12287.800	1333.000	10.848	0.33	**3**
11	Painting of MV Poles & Structures	no	14039.000	13528.100	1367.000	10.105	0.20	**2**
12	Muffler concreting of pole bases	no	14039.000	13528.100	81.000	0.599	0.01	**2**
B	**LV Line**							
1	Survey and Jungle clearing	km	906.588	908.715	776.581	85.459	2.56	**3**
2	Digging of holes for LV Poles	no	17395.648	17312.924	12115.000	69.977	2.80	**4**
3	Digging of holes for stays	no	9526.360	9198.840	2564.000	27.873	0.84	**3**
4	Transportation of LV Poles & Fittings	no	17395.664	16324.944	12360.000	75.712	3.03	**4**
5	Erection of LV Poles	no	17395.664	17264.344	8574.000	49.663	1.99	**4**
6	Erection of stays	set	9528.010	9230.530	491.000	5.319	0.16	**3**
7	Erection of LV Fittings	no	17678.348	17197.996	1100.000	6.396	0.13	**2**
8	Transportation of Conductors & accessories	km	1253.978	1085.068	227.000	20.920	0.84	**4**
9	Stringing of Conductors	km	1210.221	973.547	30.171	3.099	0.12	**4**
10	Painting of LV Poles	no	17395.276	17251.026	1510.000	8.753	0.18	**2**
11	Muffler concreting of pole bases	no	17395.276	17251.026	0.000	0.000	0.00	**2**
C	**Substations**							
1	Transportation of Transformers and substation structures	no	655.000	654.000	60.000	9.174	0.64	**7**
2	Erection / construction of substation structures	no	655.000	654.000	58.000	8.869	0.35	**4**
3	Installation of Transformers with accessories	no	655.000	654.000	0.000	0.000	0.00	**4**
4	Substation Earthing	no	1831.000	1828.000	21.000	1.149	0.02	**2**
D	**Service Connections**							
1	Releasing of service conection	no	9498.000	9528.000	0.000	0.000	0.00	**2**
2	Installation of energy meters	no	9473.000	9503.000	0.000	0.000	0.00	**1**
	Total Progress						**31.88**	**100.00**

Source: BPC RED

RED has six regional RECD offices. These offices supervise all the RE works as well as inventories at the regional and micro stores. The regional offices are responsible from obtaining environmental clearance including public consensus to service connections.

The entire tendering of construction work is managed by RED. The contractors are responsible for transporting the allocated materials from the regional or micro stores to their site, and for the construction of the lines. Under the current implementation system, the contractors need not procure the equipment on their own. This enables small local contractors without trading capacity to enter the bid directly. The Construction Development Board registers all the civil contractors and classifies them into three categories, namely: A, B and C. RE is structured to allow small C-ranked contractors to enter the bid by dividing the work into packages worth less than Nu.5 million.

Once a construction package is fully complete and ready, it is energized in the presence of ESD responsible for that area, and the system is handed over to ESD for onward O&M.

3.3.5 Financial and Physical Accounts

Table-3.3.3 shows the profit/loss statement of BPC at the end of 2009. The revenue had increased by 37% to Nu.2,161 million and the profit after depreciation by 6% to Nu.732

million. Table-3.3.4 shows the balance sheet of BPC and Table-3.3.5 shows the cash flow statement. At the end of 2009, BPC had an overall asset of Nu.12 billion, with more than 10% of which was its net asset. In terms of cash, BPC had more than Nu.1.7 billion by accumulating Nu.626 million in that year. Note-1, -2, -3 and -4 are shown in Table-3.3.6 (1/2) and -3.3.6 (2/2).

Table-3.3.3 BPC Profit and Loss Statement, Dec. 31, 2009

PROFIT AND LOSS ACCOUNT FOR YEAR ENDED 31st DECEMBER 2009 (Unit: Nu)

	2009	2008	As per budget	Variance with 2008	Variance with Budget
PARTICULARS					
INCOME					
Electricity Revenue	2,161,087,000	1,572,250,000	2,321,051,000	37%	-7%
Wheeling	675,602,000	740,297,000	665,528,000	-9%	2%
Other Revenue	62,798,000	76,156,000	59,876,000	-18%	5%
Total	**2,899,487,000**	**2,388,702,000**	**3,046,455,000**	**21%**	**-5%**
EXPENDITURE	0	0	0		
Purchase of Power	779,288,000	457,506,000	850,330,000	70%	-8%
Employee Cost	434,656,000	370,334,000	521,389,000	17%	-17%
Operation and Maintenance Expenses	120,862,000	127,321,000	153,524,000	-5%	-21%
Administration and Other Expenses	40,123,000	36,013,000	57,946,000	11%	-31%
Finance Charges	112,659,000	121,176,000	151,795,000	-7%	-26%
Prior period adjustments	-9,480,000	-18,739,000	0		
Less Charged to Capital	0	0	-82,497,000		
Total	**1,478,108,000**	**1,093,611,000**	**1,652,488,000**	**35%**	**-11%**
Profit before Depreciation	1,421,379,000	1,295,091,000	1,393,967,000	9.75%	2%
Depreciation	434,927,000	367,964,000	394,133,000	18%	10%
Profit after Depreciation	986,452,000	927,127,000	999,834,000	6%	-1%
Provision for Tax	254,015,000	242,074,000	240,653,000	5%	6%
Excess assessed Tax for earlier years	-	15,441,000	-		
Profit after tax	732,437,000	669,612,000	759,182,000	9%	-4%
Proposed Dividend	333,109,000	151,220,000	167,020,000	120%	99%
Transfer to Insurance Reserve	1,832,000	22,460,000	6,055,000	-92%	-70%
Profit(Loss) for the period	397,496,000	495,932,000	586,106,000	-20%	-32%
Balance brought forward	872,080,000	376,148,000	872,080,000		
Balance carried to Balance Sheet	1,269,575,000	872,080,000	1,458,186,000		

Source: BPC

Table-3.3.4 BPC Balance Sheet, Dec. 31, 2009

BALANCE SHEET AS AT 31st DECEMBER ,2009

PARTICULARS	Schedules		As at 31st December 2009 Amount (Nu)	As at 31st December 2008 Amount (Nu)
SOURCES OF FUND				
Shareholders' Fund				
Share Capital	1		7,258,771,000	5,886,485,000
Reserves and Surplus	2		2,343,672,132	2,815,355,845
			9,602,443,132	**8,701,840,845**
Loan Funds	3		2,518,789,820	2,260,427,102
Total			**12,121,232,952**	**10,962,267,947**
APPLICATION OF FUNDS				
Fixed Assets	4			
Gross Block		11,760,087,034		11,302,037,304
Less- Depreciation		2,354,721,911		1,928,067,519
Net Block		9,405,365,122		9,373,969,785
Capital Work in Progress		1,387,106,350		536,400,606
			10,792,471,472	**9,910,370,392**
Current Assets, Loans and Advances				
Inventories	5	369,996,149		318,155,573
Debtors	6	199,233,517		106,324,812
Cash and Bank Balances	7	1,785,694,297		1,159,052,228
Other Current Assets	8	337,765,215		103,744,558
Loan and Advances	9	359,351,198		260,393,460
Total Current Assets		**3,052,040,375**		**1,947,670,631**
Less: Current Liabilities and Provisions				
Current Liabilities	10	701,329,446		330,212,283
Provisions	11	1,021,949,450		565,560,793
Total current liabilities and Provisions		**1,723,278,896**		**895,773,076**
		1,328,761,480		1,051,897,555
Net Current Assets			**1,328,761,480**	**1,051,897,555**
Total			**12,121,232,952**	**10,962,267,947**

Notes on Accounts 19

Schedule 1 to 11 and Schedule 19 form an integral part of the Balance Sheet

In terms of our separate report of even date

Source: BPC

Table-3.3.5 BPC Cash Flow Statement, Dec. 31, 2009

	For the period from Ist January to 31st December 2009	For the period from Ist January to 31st December 2008
	Amount (Nu).	Amount (Nu).
Net cash flow from operating activities (Note - 1)	1,671,191,048	1,310,974,801
Returns on investments and servicing of finance (Note 2)	(249,958,723)	(200,791,345)
Tax paid during the year	(242,074,346)	(132,978,953)
Capital expenditure (Note 3)	(1,312,153,374)	(976,329,467)
Net cash inflow/(outflow) from investing activities	**(1,804,186,442)**	**(1,310,099,765)**
Net cash inflow/(outflow) before financing	(132,995,394)	875,037
Financing (Note 4)	759,637,464	355,474,806
Net cash inflow/(outflow) from financing activities	759,637,464	355,474,806
Increase/(Decrease) in cash	**626,642,070**	**356,349,842**
Opening cash and cash equivalents	1,159,052,228	802,702,385
Closing cash and cash equivalents	1,785,694,297	1,159,052,228
Cash Inflow	**626,642,070**	**356,349,842**

In terms of our separate report of even date

Source: BPC

Table-3.3.6 (1/2) Notes for Cash Flow Statement (1/2)

Notes for cash Flow Statement

Note - 1. Net Cash flow from Operating Activities

		For the period from Ist January to 31st December 2009		For the period from Ist January to 31st December 2008
		Amount (Nu).		**Amount (Nu).**
Indirect Method				
Net profit before tax/operating profit		986,451,893		927,127,400
Add: Increase in Capital Reserve				-
Add back: Depreciation charges	434,927,367		367,963,781	
Interest payable	112,659,178		121,175,732	
Prior Period Depreciation	-		-	
Loss on sale of fixed assets		547,586,545	-	489,139,513
Deduct:- Profit on sale of fixed assets	4,875,074		2,099,359	
Interest receivable	13,920,455		20,384,387	
		18,795,529		22,483,746
		1,515,242,908		**1,393,783,168**
(Increase)/Decrease in stock		(51,840,576)		93,849,518
(Increase)/Decrease in Debtors		(92,908,705)		55,683,681
(Increase)/Decrease in Loans & advances		(98,957,738)		(30,203,862)
(Increase)/Decrease in other current assets		(234,020,656)		(76,944,472)
Increase/(Decrease) in Creditors		633,675,815		(125,193,232)
Net cash flow from operating activities		**1,671,191,048**		**1,310,974,801**

Note - 2 Returns on investments and servicing of finance

		2009 Amount (Nu).	2008 Amount (Nu).
Interest received		13,920,455	20,384,387
Interest paid		112,659,178	121,175,732
Dividends paid		151,220,000	100,000,000
Dividend received		-	-
	Total	**(249,958,723)**	**(200,791,345)**

Note - 3 Capital expenditure

		2009 Amount (Nu).	2008 Amount (Nu).
Payments to acquire intangible fixed assets		-	-
Payments to acquire tangible fixed assets		(473,981,430)	(1,745,006,723)
Payments for capital work-in -progress		(850,705,743)	761,192,933
Receipts from sales of tangible fixed assets		12,513,799	7,484,323
	Total	**(1,312,153,374)**	**(976,329,467)**

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Source: BPC

Table-3.3.6 (2/2) Notes for Cash Flow Statement (2/2)

Notes for cash Flow Statement

Note -4 Financing

Issue of Shares & Debentures-cash		-	-
Issue of Shares & Debentures-other than cash		1,372,286,000	1,494,000
Increase in Capital reserve		(871,011,254)	510,531,636
Loan taken		258,362,718	(156,550,830)
	Total	**759,637,464**	**355,474,806**

Source: BPC

3.3.6 O&M

ESD is responsible for the O&M of the distribution network once the construction is fully complete, commissioned, and handed over by RED.

3.3.7 Performance-Based Incentive System

BPC has a strong Performance-Based Incentive System (PBIS) which is used as basis for determining bonuses to be granted to employees of various divisions and departments. Targets are set for each department on the activities carried out on annual basis. At the end of the year, the achievements are evaluated. Bonus payouts are decided based on the achievements of the targets.

3.4 Review of Current RE Program

3.4.1 Overall Situation

At present, ADB RE-4 Project and JICA RE-1 Project have been implemented to supply power to remote areas. The RGoB aims to provide “Electricity for All by 2013”. Hence, the role of ADB RE-5 Project and JICA RE-2 is to achieve this target. Consequently, all people in Bhutan including those in remote areas will be able to enjoy life with electricity.

Meanwhile, the BPC, as an implementing agency, may not have big RE projects similar to the above. However, it implements the following works to supply good quality and enough electricity to the customers:

1) Upgrading of existing distribution facilities
2) Rehabilitation of aged facilities

3) Repair works
4) Small scale RE projects

According to the recommendation of JBIC SAPROF Report (March 2006), BPC established six RECDs and ten RECSDs to implement and supervise/monitor the project at site. Its number of personnel consequently reached 163, which are all well-trained to implement RE projects.

Accordingly, it is judged that BPC has enough capability to implement the ADB RE-5 and JICA RE-2 projects at the same time. However, after completing these projects, BPC may need to modify their organogram accordingly.

Aside from construction works, the customers may request for better quality electricity and better services, which BPC is supposed to address.

It is noted that BPC is an enterprise who owns transmission network and distribution facilities in the whole of Bhutan. Hence, it has initiated the on-going replacement of overhead ground wire (OHGW) with optical ground wire (OPGW) to promote new business opportunities.

In conclusion, the capability development of personnel will be the key issue in providing good quality services to customers.

3.4.2 Procurement

BPC's PSD in the headquarter conducts tenders for the procurement of materials such as poles, conductors, and transformers on a bulk basis firstly, for economic reason of attaining cheaper prices with good quality materials.

At the time of procurement of materials, drawings for approval should be carefully checked apart from conducting factory inspection in order to avoid problems at sites such as drilling of materials.

3.4.3 Inventory Management

All materials purchased in the international market are delivered to the central store in Phuentsholing. Meanwhile, all information are managed and controlled through management information systems (MIS).

It is very important that materials are delivered on time by the manufacturer.

The most important issue is the timely delivery of materials to meet the request received from site so that no idle time will occur. Even if small materials, such as stay wires, are not available at the site, this affects the works considering that stringing works have to be suspended due to the delay in the installation of stay wire.

To avoid such idle time at the site, delivery of materials to the central store from the manufacturer shall be controlled.

3.4.4 Field Manpower

As mentioned in Section 3.4.1, BPC field manpower has enough capability and experience to supervise/monitor the project.

3.4.5 Detailed Line Planning

The current procedure of distribution line planning is as follows:

1) Initially plan using GIS map
2) Confirm route at site using GPS
3) Input GPS data to GIS
4) Estimate BOQ based on updated GIS information

Therefore, all works for tendering are processed on computerized basis. Such procedure has been well adopted for big projects.

There are no feeder-wise diagram and ledger of planned facilities. However, the JICA RE-2 Project is the last big project as mentioned before. After this, only small scale works such as augmentation and rehabilitation may be initiated and hence, it is beneficial and recommendable to do the works by referring to feeder-wise diagram together with GIS.

JPST faced difficulty in understanding the feeder information only from GIS map.

3.4.6 Tendering

In the JICA RE-1 Project, few packages had to be re-tendered because the contractor abandoned the contact even if they had to pay penalty for contractual default. In the implementation of JICA RE-2 Project, re-tendering of package(s) should be avoided because of time constraint.

Accordingly, it is required to confirm the proposal submitted by the candidate contractor based on the construction schedule and their ability to work considering such amount. Especially, for contractors engaging in contract for two or three packages, their construction schedule should be carefully checked for all the packages.

Also, it is important to give all the information before local tendering is carried out, especially regarding the project site conditions. This is intended to avoid future contractual problems.

Accordingly, no idle time shall be allowed to realize the completion date of the project as mentioned above.

CHAPTER 4 PROJECT SCOPE

4.1 On-Grid Electrification

In consultation with JICA, ADB and the Austrian Government, the Bhutanese Government has divided the remaining rural electrification tasks into three packages by dzongkhag (district). The region that JICA is responsible for covers 11 dzongkhags which are mostly located in the west while ADB's are located in the east. These 11 dzongkhags are Chukha, Dagana, Haa, Paro, Pemagatshel, Punakha, Samtse, Sarpang, Trangsa, Tsirang, and Wangdue Phodrang.

The original request for electrification was submitted by Department of Energy (DOE) after surveying and determining the alignments for middle voltage (MV) and low voltage (LV) lines as well as the location of pole-mounted transformers to extend the power grid to the target villages, based on the villages designated as "on-grid" by the JICA REMP.

After consultation with BPC and DOE, the JICA Preparatory Survey Team (JPST) has proposed the addition of two project components to increase the reliability of power supply in the Project areas. First of the components is overhead shield wire and counterpoise installation to reduce lightning damages, and the other is automatic reclosing circuit breakers.

4.1.1 Detailed Route Survey of Target Sub-project

Conducted under JICA support in 2005, REMP connected all non-electrified villages in Bhutan to the medium voltage distribution lines in a Geographical Information System (GIS). This was undertaken using various digital spatial data in conjunction with the surveyed baseline database of villages. GIS enabled REMP to obtain efficient management of spatial data on a computer. However, REMP distribution lines were formulated only in a desktop study with the baseline villages' center points assumed for transformer locations. Based on the REMP guiding results, different RE projects are formulated based on the availability of funds and donors since major RE projects in Bhutan are donor-funded (ADB and JBIC are two major donors envisaged for the 10th FYP). Consequently, the design of these RE projects are undertaken by consultants hired by respective donors. Similarly, the JICA RE-2 project formulation is taken up by JPST for the following objectives:

- ✓ Review of the need for the project;
- ✓ Preparation of the project scope (selection of target beneficiaries based on a set of criteria);
- ✓ Technical design of the rural distribution expansion;
- ✓ Village survey in order to locate target villages and households, estimate demand, size transformers and design line within the village;
- ✓ Route survey in order to determine the optimum line route and calculate line lengths;
- ✓ Distribution system design (expansion and upgrading of 33 and 11 kV, transformer, sizing and placement, LV line design);
- ✓ Cost estimation of the project;
- ✓ Preparation of implementation plan, arrangements and schedule; and
- ✓ Study of environmental and social considerations, including preparation of application for

environmental clearance, and preparation of environmental monitoring plan.

The detailed line route survey was carried out by BPC and local consultants mainly to determine the optimum line routes as confirmed by topographic and environmental conditions. The route survey also helps to calculate the length of distribution lines and accurately estimate the construction cost. Furthermore, the surveyed route will be modified from the REMP route with consideration on forest preservations, local geographical features, and right to property problems such as land ownership.

4.1.2 Methodology of Detailed Route Survey

The formulation of distribution lines in REMP was done by desktop study as stated above and it uses the geographical features made with GIS. In this JICA RE-2 study, the JPST used the BPC surveyed field data of the routes formulated in REMP. In earlier project formulations like JICA RE-1 and ADB/RE-4, local consultants were organized and deployed for the line routes and village survey. For this activity, the consultants usually seek the assistance of the local BPC/ESD staff and concerned village headman. The experience was that the accuracy of the village survey was determined by the presence and active participation of both BPC staff and village headman. However, there had been instances when the village headman or the BPC staff members were not available during the survey. During consultations with stakeholders, it was suggested that BPC should undertake the remaining line route survey instead of the consultants since the local BPC knows the terrain and local conditions better. Thus, the BPC organized to survey all remaining REMP line routes after the ADB/RE4 and JICA RE-1 projects. The acquired field data are then compiled in a database by using GIS. The methodology used for the route survey is as follows:

1. BPC pooled their field staff from different ESDs and provided training for about a week before the route survey at the Begana Central Maintenance Division (CMD). The training was on the methodology that is to be adopted for the route survey.
2. The line routes for the survey were prepared as per the REMP routes during the training and selection of teams for target dzongkhag/route-wise field surveys. The teams were listed and dispatched to the field after the training.
3. Location information was acquired using Global Positioning System (GPS) and other associated attribute data through this field survey.
4. The data of the detailed route survey was acquired in the site survey while walking along the planned line. The surveyor selected the routes in the field considering actual condition and also selecting the appropriate point of the pole position. The surveyors recorded location information using GPS. Based on the proposed distribution line route, the surveyors selected the place where electricity poles are erected, and acquired location information of each pole's erection point. The route point was carefully selected at suitable intervals that provided a direct view of the former point using GPS.
5. Through this route survey, data like accurate GPS route information of distribution lines,

and an associated attribute data such as environmental information and village information were acquired.

6. The acquired data through this detailed route survey covers the following three topics:

- ✓ Local information of the planned distribution lines,
- ✓ Information for environmental clearance, and
- ✓ Village information for the demand forecast and design of transformer and LV line.

There was possibility for REMP route modification according to the actual site condition because the planned REMP route was prepared through the desktop study which is based on geographical features data made by using GIS. Route modification could be the cause of the following items according to the judgment of the surveyors:

- ✓ Terrain type,
- ✓ Landslide and erosion,
- ✓ Archeological and cultural heritage sites,
- ✓ Tourist sites,
- ✓ Least cost options,
- ✓ Environmental problems, and
- ✓ Land use/land ownerships.

8. The survey items of the detailed route survey are covered in Table-4.1.1 below.

Table-4.1.1 Survey Items of the Detailed Route Survey

Survey_ID	GPS Waypoint.
Latitude	GPS Latitude Decimal coordination.
Longitude	GPS Longitude Decimal coordination.
Elevation	GPS Elevation.
Tap_Off	Tap Off Branch name.
Village ID	Un-Electrified Village ID.
Road information	The surveyor makes note for observations of the road condition as follows: 1: Mortable Road 2: Foot Path 3: No Road
Land use type	The surveyor makes note for observations of vegetation and land Use as follows: 1 : Urban Area 2 : Exposed/Rocky 3 : Orchards 4 : Scrub/Bushes 5 : Broadleaf forest 6 : Conifer forest 7 : Trees for domestic use 8 : Pasture, grazing 9 : Paddy field, wet land, marsh 10 : Rain-fed dry land 11 : Shifting Cultivation
Terrain Type	The surveyor makes note for observations of the surface terrain type as follows: 1 : Fairly flat 2 : Gentle $< 15^0$ 3 : Medium 15^0 to 45^0 4 : Steep $> 45^0$
Land ownership	The surveyor makes note for the land ownership as follows: 1 : Public 2 : Private
Photo ID	Input Photo ID. Refers to Digital Camera.
Remarkable	Input remarkable topics, example: The distribution line cross over the river, road, modification of REMP proposed line, etc.

9. Data output: In this study, two kinds of feeder-wise data (Excel and GIS format) were acquired from the detailed route survey. The GIS database was prepared by BPC for three types of data format namely, point data, line data, and polygon data. The attribute data of the point and line data were also prepared based on all new database items from the route survey.
10. Review of the Data Output by JPST: The database prepared by BPC above was acquired by the JPST for JICA RE-2 and it was reviewed by analyzing the line routes and plotting GIS maps. It was observed by the JPST that some lines were missing in the GIS maps for many feeders that need clarifications/re-confirmation from the field. A list of such data was prepared and local consultants were involved by the JPST for such clarifications and re-confirmation of GPS data points of the missing lines.
11. The local consultants, led by Mr. R. N. Adhikari, conducted the required field surveys with the help of GPS. He helped the JPST to clarify and fill-in the missing line data while preparing a proper database for the JICA RE-2 RE Project preparation. Accordingly, the JBIC RE-2 project scope is finalized by summing up the target feeders from the database items.

Table 4.1.2 shows the man-days taken to carry out the detailed route survey under the ARE Project by BPC. The survey started in the mid of November 2008 and completed by the end of Feb. 2009.

The Detailed route survey to clarify and fill-in the missing line data was carried out by three JPST's local consultants for a total 81 days (from May to June 2010) in Dagana, Haa, Sarpang, Trongsa, Wangduephodorang dzongkhags

Table-4.1.2 Man-days for the detailed route survey conducted by BPC

Sl.#	Dzongkhag	No. of Households	Length of MV line (Km)	No. of groups to be sent	No. of days for actual survey		No. of days for travel	Total no. of days for survey	Total no. of days/Group
					MV	LV			
1	Mongar	1,578	99	3	17	105	10	**132**	**44**
2	Zhemgang	115	5	1	1	8	8	**17**	**47**
3	Trongsa	301	23		4	20	6	**30**	
4	Thimphu	17	1	1	1	2	2	**5**	**37**
5	Chhukha	332	23		4	22	6	**32**	
6	Gasa	219	28	1	5	15	10	**30**	**30**
7	Dagana	417	29	1	5	28	8	**41**	**48**
8	Tsirang	28	2		1	2	4	**7**	
9	Haa	18	2	1	1	2	4	**7**	**48**
10	Paro	60	12		2	4	4	**10**	
11	Punakha	16	4		1	1	4	**6**	
12	Wangduephodrang	241	26		5	16	4	**25**	
13	Lhuentse	95	9	1	2	7	8	**17**	**43**
14	Trashigang	184	27		5	13	8	**26**	
15	Pema Gatshel	255	22	1	4	17	12	**33**	**33**
16	Samdrup Jongkhar	1,198	54	2	9	80	16	**105**	**53**
17	Samtse	952	49	2	8	64	16	**88**	**44**
18	Sarpang	946	58	2	10	63	12	**85**	**43**
19	Trashi Yangtse	494	27	1	5	33	6	**44**	**44**
	Total	**7,466**	**501**	**17**	**90**	**502**	**148**	**740**	

Note:

i Each group consisted of 2 persons (Supervisor/Linemen/Technician) from BPC.

ii Each group was assisted by 2 (two) local persons from the village.

iii Number of households and MV line length is the initial scope.

4.2 Off-grid electrification

The off-grid electrification by SHS is the out of scope of the JICA RE-2 Project. JPST conducted a site survey for technical support for O&M of existing SHSs and ADB-funded SHS instead of planning the SHS project as a Japanese ODA loan project.

The detail of the survey is described in Chapter 9.

4.3 Design for the Project

4.3.1 Design Consideration

The "Electricity for All" by June, 2013 is publicly announced by RGoB, to realize the national target of electrification. ADB RE-5 and JICA RE-2 are planned to be implemented at the same time.

Actually, RE-5 Project by ADB and RE-2 Project by JICA are considered to be two projects from donor side. However, both projects aimed at the realization of "electrification for all". Therefore, these two projects are considered as one project from Bhutan side.

Accordingly, the basic consideration including design concept, specifications and packaging of the project components for both projects should be coordinated.

Regarding the specifications, JICA RE-2 will basically also apply the PPTA's specifications.

4.3.2 Difference in Design

As mentioned in the previous sub-clause 4.3.1, at first JPST adopted the design concept of PPTA for the pole allocation, which means the standard span length is to be 100 m, however, sag and tension calculation revealed that this span length is too long to the AAAC conductor from the viewpoint of mechanical strength. Hence, the standard span length of 80 m has been adopted to AAAC covered conductors.

4.3.3 Comparison of Steel Pole and Telescopic Poles

(1) Workability and Technical Issues

The steel tubular poles have been used as supports for medium voltage (MV) lines and low voltage (LV) distribution lines. However, it becomes more difficult to transport poles to remote areas by human transportation due to the lengths and unit weights of the poles. It was studied and discussed to reduce the burden to the workers and reduce the construction period by shortening the carrying time through human transportation. Finally, it was decided to use telescopic poles as supports instead of steel tubular poles.

The requirement of newly introduced telescopic poles should have equivalent or higher specifications compared with steel tubular poles, which have been used up to the present. Table-4.3.1 shows that newly introduced telescopic poles meet the requirements in place of steel tubular poles. Telescopic poles have an advantage that the surface of the pole is galvanized, hence application of anticorrosive paint at site is not required.

Table-4.3.1 Specifications of Tubular and Telescopic Poles

Voltage	Steel Tubular pole		Telescopic pole		
	Length	Strength	Length	Strength	Remarks
LV	7.0 (m)	1.81 (kN)	9.0 (m)	3.29 (kN)	
11kV	9.0 (m)	1.93 (kN)	11.2 (m)	3.29 (kN)	Without shielding wire
			12.0 (m)	3.29 (kN)	With shielding wire
33kV	10.0 (m)	2.02 (kN)	11.2 (m)	3.29 (kN)	Without shielding wire
			12.0 (m)	3.29 (kN)	With shielding wire

Source: BPC

(2) Cost Comparison

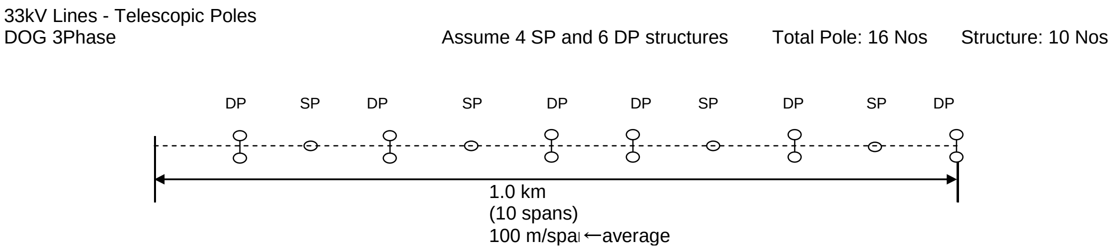
The comparison on the material cost per 1 km between tubular and telescopic poles with 33 kV, 3-phase dog conductor, fittings and civil materials is shown in Table-4.3.2 and 4.3.3. The assumption of the standard span for each pole is as shown in Figure-4.3.1 and 4.3.2.

According to the basic design of ADB RE-5, the allocation schedule for telescopic poles per one kilometer consists of six sets of double pole arrangement, and four sets of single pole arrangement. Accordingly, the average span length is to be 100 m, and 16 poles are required for one kilometer line length.

The material cost of telescopic poles is Nu.660,331 per km, which is 8.3% more expensive than that of tubular poles because of the high unit cost of telescopic pole itself, though the shorter standard span of telescopic poles allows less number of necessary poles, fittings and civil material. In the case of other types of conductor, the difference in cost shows almost the same trend.

(Prepared by JPST in accordance with BPC's design standard)

Figure-4.3.1 Standard Span for Tubular Poles



(Prepared by JPST in accordance with basic design in ADB RE-5)

Figure-4.3.2 Standard Span for Telescopic Poles

Table-4.3.2 Bill of Materials for 33 kV line with Tubular Pole per 1 km

Bill of Materials for 33 kV single circuit line (3 Φ) with DOG conductor
Length of line : 1.000 Km

Sl.#	Description of items	Unit	Total quantity	Unit cost (Nu.)	Total cost (Nu.)
I	**Foreign Materials**				
1	Steel tubular poles 10 mtr. long with base plate, fixing bolts, etc.	No.	23	9,512.8	218,794.4
2	Single pole cross arm assembly complete with M&U clamps, nuts, bolts and other accessories.	Set	11	967.5	10,642.4
3	Top hamper assembly complete with M&U clamps, nuts, bolts and other accessories.	Set	11	515.1	5,666.1
4	Cross arm assembly for H-frame (O) complete with M clamps, nuts, bolts and other accessories.	Set	6	3,965.1	23,790.6
5	Cross brace arm assembly for H-frame with full clamps, nuts, bolts and other accessories.	Set	6	2,837.6	17,025.8
6	G.I. stay set assembly (1 no. turn buckle, 1 no. stay rod with base plate)	Set	12	1,154.6	13,855.2
7	33 kV stay insulator	No.	12	89.7	1,076.7
8	G.I. stay wire 7/8 SWG	Kg	120	80.0	9,599.3
9	Stay clamp assembly	Set	12	283.2	3,398.7
10	Polymer Strain Insulator 33kV	Set	36	1,323.7	47,652.6
11	33 kV pin insulator assembly with pin	Set	33	787.5	25,987.8
12	Preform dead end terminations - DOG	No.	36	161.0	5,796.0
13	Tension joints - DOG	No.	9	250.8	2,257.1
14	ACSR conductor - DOG	Km	3.100	59,455.0	184,310.5
15	P.G. clamp for DOG	No.	18	55.1	992.4
16	Spike earthing set 2500x20 mm complete with connecting plates, nuts & bolts with 4 metre G.I. wire 8 SWG .	Set	23	450.2	10,355.4
17	Barbed wire	Kg	84	80.0	6,719.5
18	Danger plate (enamelled) 33 kV	No.	17	141.6	2,407.4
19	Bituminous aluminium paint	Ltr.	0	136.9	0.0
20	Bituminous black paint	Ltr.	8	73.9	591.6
21	Miscellaneous items (1% on above)				5,909.2
	Foreign material cost (Nu.)				**596,828.6**
II	**Local Materials**				
21	Cement	MT	1.3	3,440.0	4,472.0
22	Sand	Cft	42	23.0	966.0
23	Stone chips 20 mm	Cft	94	23.0	2,162.0
24	Boulder for double pole bonding	Cft	94	57.5	5,405.0
	Local material cost (Nu.)				**13,005.0**
	Total material cost (Nu.)				**609,833.6**

Source: Prepared by JPST

Table-4.3.3 Bill of Materials for 33 kV line with Telescopic Pole per 1 km

Bill of Materials for 33 kV single circuit line (3 Φ) with DOG conductor
Length of line : 1.000 km

Sl.#	Description of items	Unit	Total quantity	Unit cost (Nu.)	Total cost (Nu.)
I	**Foreign Materials**				
1	Steel telescopic poles 11 mtr. long with base plate, fixing bolts, etc.	No.	16	18,254.7	292,075.2
2	33 kV single pole cross arm assembly complete with M&U clamps, nuts, bolts and other accessories.	Set	4	967.5	3,870.0
3	33 kV top hamper assembly complete with M&U clamps, nuts, bolts and other accessories.	Set	4	515.1	2,060.4
4	33 kV cross arm assembly for H-frame (O) complete with M clamps, nuts, bolts and other accessories.	Set	6	3,965.1	23,790.6
5	33 kV cross brace arm assembly for H-frame with full clamps, nuts, bolts and other accessories.	Set	6	2,837.6	17,025.8
6	G.I. stay set assembly (1 no. turn buckle, 1 no. stay rod with base plate)	Set	10	1,154.6	11,546.0
7	33 kV stay insulator	No.	10	89.7	897.2
8	G.I. stay wire 7/8 GSW	kg	120	80.0	9,599.3
9	Stay clamp assembly, 33 kV	Set	10	283.2	2,832.2
10	Polymer Strain Insulator 33kV	Set	36	1,323.7	47,652.6
11	33 kV pin insulator assembly with pin	Set	12	787.5	9,450.1
12	Preform dead end terminations - DOG	No.	36	161.0	5,796.0
13	Tension joints - DOG	No.	9	250.8	2,257.1
14	ACSR conductor - DOG	km	3.100	59,455.0	184,310.5
15	P.G. clamp for DOG	No.	18	55.1	992.4
16	Spike earthing set 2500x20 mm complete with connecting plates, nuts & bolts with 4 metre G.I. wire 8 GSW .	Set	16	450.2	7,203.8
17	Barbed wire	kg	200	80.0	15,998.8
18	Danger plate (enamelled) 33 kV	No.	10	141.6	1,416.1
19	Bituminous aluminium paint	Ltr.	0	136.9	0.0
20	Bituminous black paint	Ltr.	20	73.9	1,478.9
21	Miscellaneous items (1% on above)				6,402.5
	Foreign material cost (Nu.)				**646,655.5**
II	**Local Materials**				
21	Cement	MT	1.3	3,956.0	5,142.8
22	Sand	Cft	42	23.0	966.0
23	Stone chips 20 mm aggregate	Cft	94	23.0	2,162.0
24	Boulder for double pole bonding	Cft	94	57.5	5,405.0
	Local material cost (Nu.)				**13,675.8**
	Total material cost (Nu.)				**660,331.3**

Source: Prepared by JPST

4.3.3 Conductor Sag

(1) Conductor sag

The drawings which were prepared by PPTA in Figure-4.3.3 and 4.3.4 show that the clearance above ground to the cross arm is 7.22 m for single pole and 8.27 m for double pole, respectively. The clearance to be kept for 33 kV and 11 kV lines are specified as 6.1 m for road crossings and 5.8 m elsewhere.

As also shown in Figure-4.3.2, single poles and double poles are allocated alternately, i.e., the sag and tension of the conductors are decided to keep the aforementioned ground clearance.

The conductor sag is considered as follows to keep the ground clearance of 5.8 m (Ground clearance of 6.1 m for "road crossings" is not considered, because poles usually be constructed near the road when the MV line crosses the road.):

Conductor sag = ((7.22 – 5.8) + (8.27 – 5.8)) / 2 = 1.94 m

Therefore, the conductor tension is decided with 1.94 m sag as a maximum value.

Conditions of sag calculation are as follows:

a. Safety factor of conductor : more than 2.5
b. Wind pressure on conductor : 44.86 kgf/sqm
c. Load condition (high) : 15 ℃
d. Load condition (low) : -10 ℃

a. ACSR

The conductors for 11 kV and 33 kV MV lines consist of aluminum conductor steel reinforced (ACSR) dog and rabbit conductors with their specifications shown in Table-4.3.4.

Table-4.3.4 Specifications of ACSR Dog and Rabbit Conductors

Kind of conductor	Dog	Rabbit
Sectional area (sqmm)	118.5	61.7
Outer diameter (mm)	14.15	10.05
Weight (kg/m)	0.394	0.214
Elastic modulus (kg/sqmm)	7,990	8,400
Ultimate Tensile Strength (kg)	3,340	1,870
Coefficient of linear expansion (℃)	0.0000195	0.0000189

Source: BS 215 Part2

To decide the sag and tension, the maximum working tension of rabbit conductor for a span length of 100 m is assumed and calculated as shown in Table-4.3.5. It is decided that the maximum tension of rabbit should be 600 kgf with 1.93 m sag at 75 degree Celsius.

Same study has been made for dog conductors, and it was decided that its maximum working tension should be 1,100 kgf with 1.89 m sag at 75 degree Celsius as shown in Table-4.3.6.

Table-4.3.5 Case Study for Rabbit Conductor

Conductor Temperature (deg-C)	Max. working tension 400 (kg)		Max. working tension 500 (kg)		Max. working tension 600 (kg)	
	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)
-10	242.5	1.10	365.5	0.73	495.5	0.54
0	207.0	1.29	302.0	0.89	414.8	0.64
10	180.8	1.48	251.8	1.06	343.4	0.78
15	170.3	1.57	231.4	1.16	312.1	0.86
20	161.2	1.66	213.9	1.25	284.1	0.94
30	146.1	1.83	186.0	1.44	238.1	1.12
40	134.2	1.99	165.1	1.62	203.9	1.31
50	124.5	2.15	149.1	1.79	178.5	1.50
60	116.6	2.30	136.6	1.96	159.4	1.68
70	109.9	2.44	126.5	2.12	144.7	1.85
75	106.9	2.50	122.2	2.19	138.6	1.93
90	99.3	2.70	111.3	2.41	123.6	2.16
120	87.7	3.05	95.9	2.79	103.7	2.58

Source: Prepared by JPST

Table-4.3.6 Case Study for Dog Conductor

Conductor Temperature (deg-C)	Max. working tension 800 (kg)		Max. working tension 900 (kg)		Max. working tension 1,000 (kg)		Max. working tension 1,100 (kg)	
	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)
-10	623.1	0.79	745.7	0.66	867.2	0.57	986.0	0.50
0	513.3	0.96	613.7	0.80	719.6	0.68	827.9	0.59
10	429.0	1.15	505.9	0.97	591.8	0.83	684.7	0.72
15	395.5	1.25	461.7	1.07	537.0	0.92	620.8	0.79
20	366.8	1.34	423.5	1.16	488.8	1.01	562.9	0.87
30	321.1	1.53	362.8	1.36	410.8	1.20	466.6	1.06
40	286.9	1.72	318.2	1.55	353.5	1.39	394.4	1.25
50	260.5	1.89	284.6	1.73	311.3	1.58	341.5	1.44
60	239.7	2.06	258.8	1.90	279.4	1.76	302.3	1.63
70	222.8	2.21	238.3	2.07	254.7	1.93	272.5	1.81
75	215.5	2.29	229.6	2.15	244.3	2.02	260.2	1.89
90	197.1	2.50	207.9	2.37	219.0	2.25	230.6	2.14
120	170.7	2.89	177.7	2.77	184.7	2.67	191.7	2.57

Source: Prepared by JPST

b. AAAC covered conductor

Two kinds of AAAC (all aluminum alloy conductor) covered conductor, namely, hydrogen and fluorine, will be used in the protected area. Their specifications are shown in Table-4.3.7. The sag and tension of these conductors are studied in the same manner as the ACSR's.

Table-4.3.8 and 4.3.9 show the sag and tension of two AAACs for the span lengths of 60 m, 80 m and 100 m.

Table-4.3.9 shows that the maximum applicable span length should be 80 m with maximum working tension of 460 kgf. This maximum working tension indicates that the safety factor of the conductor for ultimate tensile strength is 2.6. Accordingly, the standard span length for AAAC conductors should be 80 m instead of 100 m in the case of ACSR.

From this view point, the maximum working tension of hydrogen is also decided to be 850 kgf with 1.86 m sag at 75 degrees Celsius as shown in Table-4.3.11.

Table-4.3.7 Specifications of Hydrogen and Fluorine

Kind of conductor	Hydrogen	Fluorine
Sectional area (sqmm)	111.3	49.48
Outer diameter (mm)	20.3	15.3
Weight (kg/m)	0.485	0.26
Elastic modulus (kgf/sqmm)	6,500	6,500
Ultimate Tensile Strength (kg)	2,470	1,200
Coefficient of linear expansion (℃)	0.000023	0.000023

Source: BPC

Table-4.3.8 Case Study for AAAC (Fluorine)

Max. working tension 400 (kg)						
Conductor Temperature (deg-C)	Span length : 60 (m)		Span length : 80 (m)		Span length : 100 (m)	
	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)
-10	279.3	0.42	225.3	0.92	192.7	1.69
0	227.0	0.52	193.0	1.08	174.0	1.87
10	185.0	0.63	168.2	1.24	159.0	2.04
15	168.1	0.70	158.2	1.32	152.6	2.13
20	153.8	0.76	149.3	1.39	146.9	2.21
30	131.2	0.89	134.8	1.54	136.8	2.38
40	114.9	1.02	123.2	1.69	128.4	2.53
50	102.8	1.14	114.0	1.83	121.3	2.68
60	93.5	1.25	106.4	1.96	115.1	2.83
70	86.1	1.36	100.0	2.08	109.7	2.97
75	83.0	1.41	97.2	2.14	107.3	3.03
90	75.2	1.56	89.9	2.32	100.8	3.23
120	64.4	1.82	79.0	2.64	90.6	3.59

Source: Prepared by JPST

Table-4.3.9 Case Study for AAAC (Fluorine)

Max. working tension 460 (kg)						
Conductor Temperature (deg-C)	Span length : 60 (m)		Span length : 80 (m)		Span length : 100 (m)	
	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)
-10	362.1	0.32	304.3	0.68	256.5	1.27
0	299.6	0.39	256.1	0.81	224.5	1.45
10	244.1	0.48	217.0	0.96	199.2	1.63
15	219.9	0.53	200.7	1.04	188.6	1.72
20	198.4	0.59	186.5	1.12	179.2	1.81
30	163.5	0.72	163.3	1.27	163.2	1.99
40	138.3	0.85	145.6	1.43	150.3	2.16
50	120.1	0.97	131.8	1.58	139.7	2.33
60	106.7	1.10	120.9	1.72	130.8	2.49
70	96.5	1.21	112.1	1.86	123.3	2.64
75	92.3	1.27	108.3	1.92	120.0	2.71
90	82.1	1.43	98.6	2.11	111.3	2.92
120	68.7	1.71	84.9	2.45	98.2	3.32

Source: Prepared by JPST

Table-4.3.10　Case Study for AAAC (Hydrogen)

Max. working tension 800 (kg)						
Conductor Temperature (deg-C)	Span length : 60 (m)		Span length : 80 (m)		Span length : 100 (m)	
	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)
-10	675.4	0.32	603.6	0.64	540.9	1.12
0	540.6	0.40	496.7	0.78	463.0	1.31
10	427.0	0.51	412.8	0.94	402.9	1.51
15	380.3	0.57	379.1	1.02	378.3	1.60
20	340.7	0.64	350.2	1.11	356.8	1.70
30	280.0	0.78	304.3	1.28	321.1	1.89
40	238.2	0.92	270.1	1.44	293.0	2.07
50	208.6	1.05	244.0	1.59	270.4	2.24
60	186.9	1.17	223.5	1.74	251.9	2.41
70	170.3	1.28	207.1	1.87	236.5	2.57
75	163.4	1.34	200.1	1.94	229.7	2.64
90	146.5	1.49	182.3	2.13	212.1	2.86
120	123.8	1.76	157.1	2.47	186.1	3.26

Source: Prepared by JPST

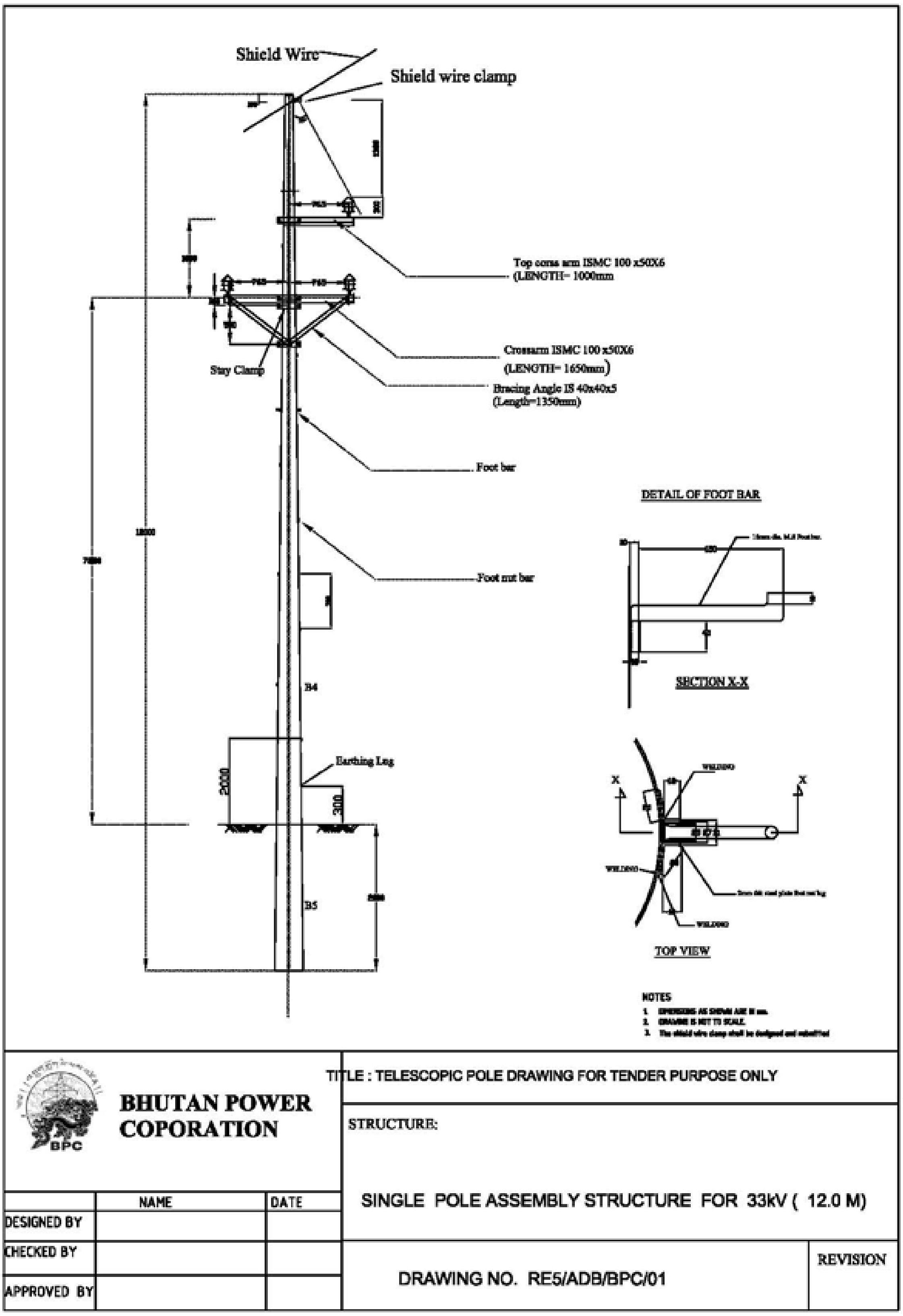
Table-4.3.11　Case Study for AAAC (Hydrogen)

Max. working tension 850 (kg)						
Conductor Temperature (deg-C)	Span length : 60 (m)		Span length : 80 (m)		Span length : 100 (m)	
	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)	Horizontal Tension (kgf)	Sag (m)
-10	741.3	0.29	674.0	0.58	609.7	0.99
0	599.6	0.36	555.1	0.70	517.5	1.17
10	475.3	0.46	458.0	0.85	444.8	1.36
15	422.4	0.52	418.1	0.93	415.0	1.46
20	376.4	0.58	383.7	1.01	388.9	1.56
30	304.8	0.72	328.8	1.18	346.0	1.75
40	255.3	0.86	288.4	1.35	312.7	1.94
50	220.9	0.99	258.1	1.50	286.3	2.12
60	196.0	1.11	234.7	1.65	265.0	2.29
70	177.3	1.23	216.1	1.80	247.4	2.45
75	169.6	1.29	208.2	1.86	239.7	2.53
90	151.1	1.45	188.6	2.06	220.1	2.76
120	126.6	1.73	161.2	2.41	191.5	3.17

Source: Prepared by JPST

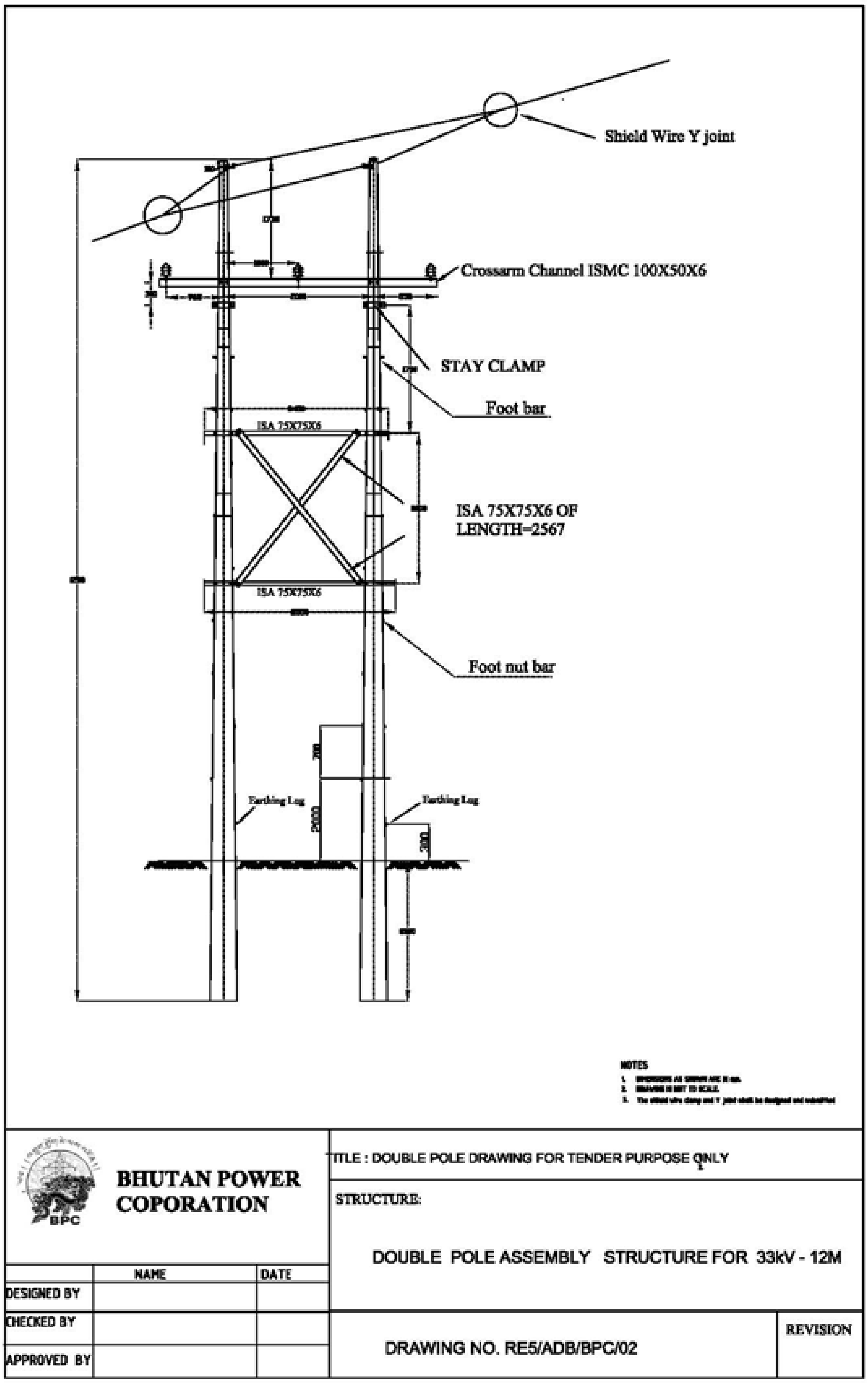
(2) Sag Calculation of Conductors

Table-4.3.5, 4.3.6, 4.3.8, 4.3.9, 4.3.10 and 4.3.11 show the summarized sag and tension of conductors.　These summarized data are obtained from Appendix-I.



Source: BPC

Figure-4.3.3 Single Pole Assembly Structure for 33 kV Prepared by ADB PPTA



Source: BPC

Figure-4.3.4 Double Pole Assembly Structure for 33 kV Prepared by ADB PPTA

4.3.4 Lightning Prone Area

(1) Analysis of Power Interruption Records and Lightning Prone Area

As mentioned in the Minutes of the Meeting between ADB and BPC (see Annexture-1 attached), the power interruption and damages on the distribution facilities especially pole mounted transformers are seriously recognized by BPC. Hence, BPC intends to take countermeasures to reduce such power interruptions and damages on distribution facilities, by installing overhead ground wire to their MV lines.

Firstly, lightning prone area in Bhutan has to be identified, as it occupies an area covering 300 km from east to west and 150 km from south to north. Also, regarding climate conditions, its southern border with India is within a subtropical zone with high precipitation while the northern area is within high mountains with low temperature and less precipitation.

Accordingly, it was considered that lightning prone area is to be identified by analyzing the power interruption records of BPC distribution facilities.

The power interruption record was gathered and managed at the Distribution & Customer Service Department (DCSD). The JPST received the power interruption records from January, 2007 through April, 2010.

The monthly data are arranged in one excel file for each dzongkhag. For analysis purposes, these data (total of 40 excel files) are converted into one excel file as a data base information with 25, 810 records.

The lightning-related data have been searched using the keywords “lightning” and “thunder”. Total of 700 records are identified as power interruption incidents due to lightning. These power interruption records are tabulated in Table-4.3.12. Said table shows that these incidents are concentrated mainly in Chukha, Pemagatsel, Samtse Sarpang and Lhuentse. These dzongkhags are located in the southern Indian border, except Lhuentse. Please refer to Appendix-H for detailed information such as fault location, influenced feeders, etc.

To identify the lightning prone area by analyzing the power interruption records due to lightning, it is assumed that power interruption will be proportional to the length of MV lines of each dzongkhag. However, it should be noted that no power interruption record is registered in Samdrup Jongkhar. (Refer to Figure-4.3.6 for the existing MV lines in Bhutan.)

According to interviews with BPC Phuentsholing (ESD), lightning frequently occurred in the Indian border including Samdrup Jongkhar. Accordingly, there is a possibility that the keyword “lightning” or “thunder” have not been used at the time of recording the power interruption due to lightning.

Therefore, it is recommended that in inputting the keyword in the power interruption record, the pull-down menu of the excel file should be used instead of manually typing the words by the person in charge. Hence, only one keyword will be used for each cause such as lightning, relay operation, maintenance and so on.

Table-4.3.12 Frequency of Power Interruption due to Lightning

Dzongkhag	Year				Sub-total
	2007	2008	2009	2010	
Bumthang	3	1	0	0	4
Chukha	42	62	27	13	144
Dagana	none	none	none	none	0
Mongar	none	none	none	none	0
Haa	0	0	0	1	1
Lhuentse	5	0	25	1	31
Mongar	none	none	none	none	0
Paro	none	none	none	none	0
Pemagatsel	134	57	70	6	267
Punakha	none	none	none	none	0
Samdrupjongkhar	none	none	none	none	0
Samtse	61	55	44	11	171
Sarpang	2	17	23	3	45
Thimphu	0	1	0	0	1
Trashigang	6	1	0	0	7
Trashiyangtse	7	0	0	0	7
Trongsa	5	0	0	0	5
Tsirang	none	none	none	none	0
Wandue	2	0	4	0	6
Zhemgang	0	1	9	1	11
Sub-total	267	195	202	36	700

Source: Prepared by JPST based on the data provided by BPC

(2) Lightning Prone Area

As mentioned in section (1), lightning prone area for the design of MV lines of BPC is identified to be within the Indian border, i.e., from west to east, Samtse, Chukha, Dagana, Tsirang, Sarpang and Pemagatsel dzongkhags. These are the coverage areas of JICA RE-2 Project.

These dzongkhags in the Brahmaptra valley along with other areas of North-East India have lightning activity close to the highest in the world and have been reported 120 days per year of lightning density[1].

(3) Month-wise Lightning

The yearly frequency of power interruption in Table-4.3.12 is classified on a monthly basis as shown in Table-4.3.13, 4.3.14 and 4.3.15. These tables show that no lightning occurs from November to January.

1 Source : http://www.mail-archive.com/assam@assamnet.org/

Table-4.3.13 Dzongkhag-wise and Monthly-wise Power Interruption due to Lightning (2007)

	Nos./hrs	Bumthang	Chukha	Haa	Lhuentse	Pemagatsel	Samtse	Sarpang	Thimphu	Trashigang	Trashiyangtse	Trongsa	Wandue	Zhemgang	Total
Jan	Times		6				4								10
	Tol duation		1.5				0.1								1.6
Feb	Times		13			21	2	1							37
	Tol duation		79.4			14.0	10.7	21.2							125.3
Mar	Times	1	4				1					1			7
	Tol duation	1.0	11.6				2.1					1.0			15.7
Apr	Times	1				28	15			2		2	2		50
	Tol duation	0.2				17.6	18.4			1.4		0.4	17.8		55.7
May	Times	1	12			27	9				7	2			58
	Tol duation	3.5	48.6			2.1	1.0				2.2	7.0			64.4
Jun	Times		5		1	12	6			2					26
	Tol duation		1.9		1.0	9.8	2.5			0.3					15.5
Jul	Times				4	46	9			2					61
	Tol duation				3.5	14.3	0.4			0.0					18.2
Aug	Times						6								6
	Tol duation						5.4								5.4
Sep	Times		2				7	1							10
	Tol duation		1.0				1.9	5.1							8
Oct	Times						2								2
	Tol duation						0.1								0.1
Nov	Times														
	Tol duation														
Dec	Times														
	Tol duation														
Total	Times	3	42	0	5	134	61	2	0	6	7	5	2	0	267
	Tol duation	4.68	144	0	4.5	57.75	42.6	26.3	0	1.7	2.2	8.4	17.8	0	309.9

(Prepared by JPST based on the data provided by BPC)

Table-4.3.14 Dzongkhag-wise and Monthly-wise Power Interruption due to Lightning (2008)

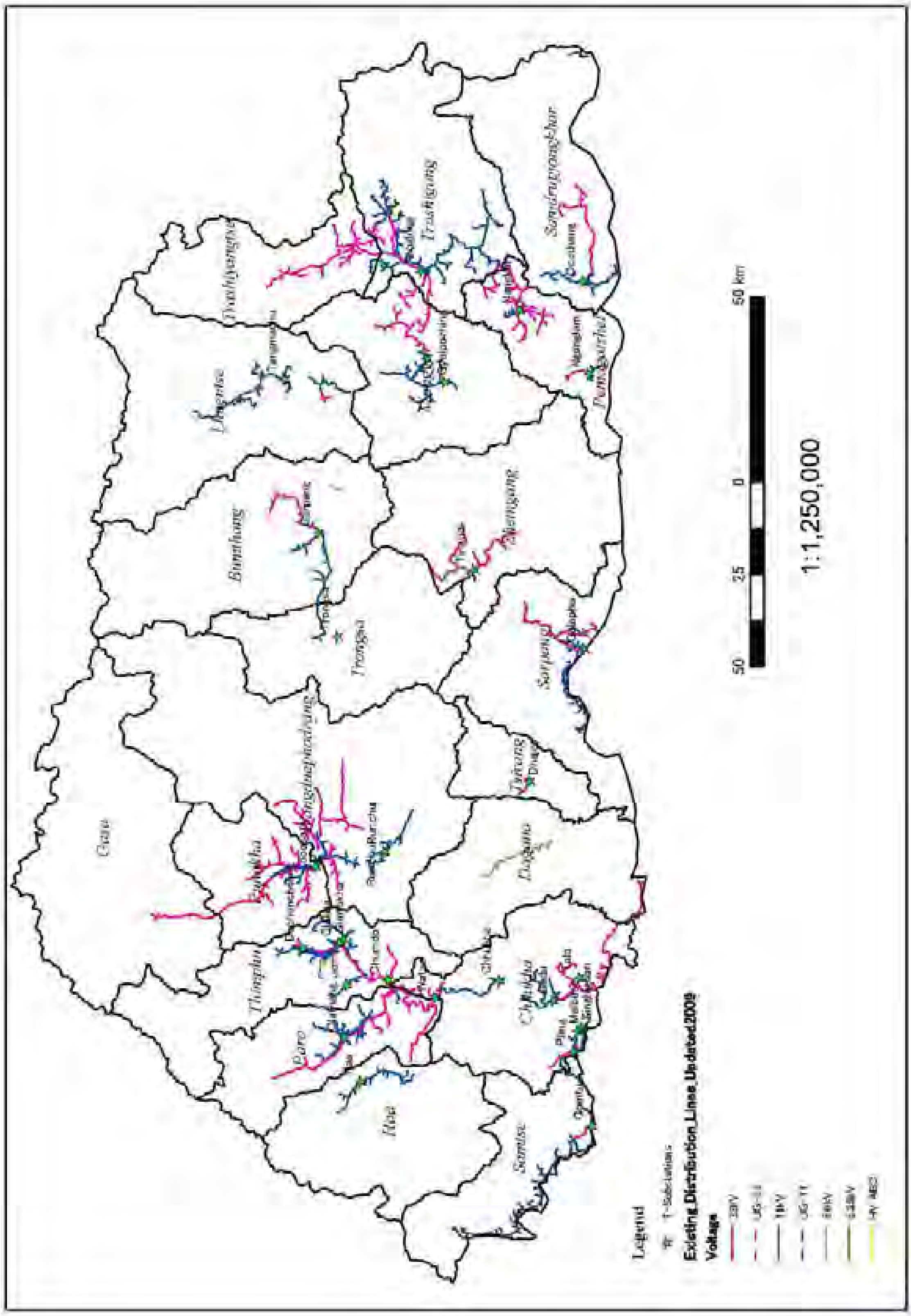
	Nos./hrs	Bumthang	Chukha	Haa	Lhuentse	Pemagatsel	Samtse	Sarpang	Thimphu	Trashigang	Trashiyangtse	Trongsa	Wandue	Zhemgang	Total
Jan	Times														0
	Tol duation														0
Feb	Times	1	1												2
	Tol duation	0.5	4.7												5.2
Mar	Times		24			3	20			1				1	49
	Tol duation		9.3			12.4	13.3			2.4				0.1	37.5
Apr	Times		15			2	5	6							28
	Tol duation		44.5			23.2	0.3	6.1							74.1
May	Times		4			12	17	2							35
	Tol duation		6.0			1.7	3.6	6.2							17.5
Jun	Times		3			2	5								10
	Tol duation		0.2			2.2	1.2								3.6
Jul	Times						2	7							9
	Tol duation						2.2	18.9							21.1
Aug	Times		5			38		2							45
	Tol duation		1.7			3.2		21.9							26.8
Sep	Times		10				6								16
	Tol duation		23.9				0.2								24.1
Oct	Times								1						1
	Tol duation								0.2						0.2
Nov	Times														
	Tol duation														
Dec	Times														
	Tol duation														
Total	Times	1	62	0	0	57	55	17	1	1	0	0	0	1	195
	Tol duation	0.5	90.3	0	0	42.7	20.8	53.1	0.2	2.4	0	0	0	0.1	210.1

(Prepared by JPST based on the data provided by BPC)

Table-4.3.15 Dzonkhag-wise and Monthly-wise Power Interruption due to Lightning (2009)

	Nos./hrs	Bumthang	Chukha	Haa	Lhuentse	Pemagatsel	Samtse	Sarpang	Thimphu	Trashigang	Trashiyangtse	Trongsa	Wandue	Zhemgang	Total
Jan	Times														0
	Tol duation														0
Feb	Times					21							2		23
	Tol duation					1.9							12.6		14.5
Mar	Times		1		2	11	1						2	9	26
	Tol duation		0.1		0.9	6.4	1.1						1.5	4.7	14.7
Apr	Times						2	2							4
	Tol duation						22.2	1.3							23.5
May	Times		11		1	18		11							41
	Tol duation		11.7		0.2	4.1		53.6							69.6
Jun	Times		8			18	17	9							52
	Tol duation		8.1			0.5	17.7	6.9							33.2
Jul	Times					2	6	1							9
	Tol duation					0.5	13.4	2.6							16.5
Aug	Times		1		22		15								38
	Tol duation		0.1		1.2		2.4								3.7
Sep	Times		2				3								5
	Tol duation		0.3				1.6								1.9
Oct	Times		4												4
	Tol duation		0.9												0.9
Nov	Times														
	Tol duation														
Dec	Times														
	Tol duation														
Total	Times	0	27	0	25	70	44	23	0	0	0	0	4	9	202
	Tol duation	0	21.2	0	2.3	13.4	58.4	64.4	0	0	0	0	14.1	4.7	178.5

(Prepared by JPST based on the data provided by BPC)



Source: BPC

Figure-4.3.6 Existing MV Lines in Bhutan

(4) Countermeasure for Lightning

To reduce the damages or influences due to lightning (induced lightning not directly striking the MV lines), lightning arrester together with overhead ground wires are commonly used. Lightning arresters are specified to protect pole-mounted transformer in accordance with the Distribution Design and Construction Standards of BPC. Together with the installation of lightning arrester, installation of overhead ground wire is recommended to reduce the grounding resistance of the MV lines.

The grounding resistance of substations (pole-mounted transformers) should be kept within or lower than the specified value (5 ohms[2] and 10 ohms[3] as per the Distribution Design and Construction Standards of BPC) to ensure the protective performance of the lightning arresters.

However, it is not easy to keep the ground resistance within the specified value due to the high soil resistivity in Bhutan, which is as high as 1,200 ohm-meter. Salt is commonly used to lower the grounding resistance together with charcoal to reduce the grounding resistance of substations. However, use of salt does not seem to maintain the performance over a long period because it is easily washed away by rain water.

The use of overhead ground wire is recommended to reduce the grounding resistance over a long period by connecting the poles which are grounded in parallel.

(5) Countermeasure for Existing facilities

No overhead ground wire is installed in the existing 33 kV and 11 kV MV lines. Furthermore, additional installation of overhead ground wire to the existing MV lines is not easy for the pole assembly.

However, it is necessary to take countermeasures to reduce the damage or influence by lightning. The only protective device for pole-mounted transformer is a lightning arrester. To secure the performance of lightning arresters, the grounding resistance is the key factor, i.e., it should be within or under the specified value, or as low as possible.

As countermeasure for reducing the grounding resistance of existing transformer poles, installation of counterpoise is recommended. The number and length of counterpoise is estimated to be 2 and 30 m, respectively.

(6) Location-wise Analysis of Lightning Faults

The location-wise analysis of lightning faults which shows the influenced feeders of each dzongkhag is summarized in Appendix-M.

2 The resistance of pipe earthing systems at distribution substations
3 The resistance of stake earths

4.4 Expansion of Scope: Quality Improvement

4.4.1 Improvement of Reliability in Power Supply

After the completion of the proposed grid extension, Bhutan will complete the RE work except for some minor additional work. The distribution network will extend to 3,000 km of MV lines at its completion covering over 95% of the rural population. After completion of the Project, the longest MV line will extend over 100 km. The larger the network becomes, the higher the chance for supply disruption. Thus, minimizing influenced areas and reducing blackout time is critical in order to maintain consumer benefits that are gained from grid extension. The measures to improve reliability of electricity service are twofold; first is the reduction of lightning damages, and second is the automatic re-closure system to reduce blackout duration from temporary short circuits and grounding fault.

4.4.2 Shield Wire and Counterpoise

After the examination of comprehensive failure records (2007-2010) that was compiled by each ESD of BPC, the JPST found out some noticeable occurrences of damages caused by lightning.

According to a “Tour Report” dated April 27, 2010, it is reported that coils of a 63kVA transformer at Upper Gangkha were burned due to heavy lightning on April 03, 2010 and same kind of failure was occurred at Shema Gangkha on April 04, 2010 due to the same cause.

And “Failure Reporting for Transformer” reported that transformer failures were occurred at Lower Gangkha, Gangkha School and Upper Shemakha due to heavy lightning on March 26, 2010.

The JPST recommends the introduction of shield wires for the lightning-prone dzongkhags of Samtse, Sarpang, Chukha and Dagaga. The total shield wire length requirement is estimated to be 290km of the new MV lines.

Another effective measure to lower the grounding resistance of transformer poles is to install counterpoises with 30 m of bare conductors that are buried horizontally in two opposite directions. It is estimated that a total of 700 transformers are to be protected with this measure with 298 to be newly installed and 402 of the existing ones.

4.4.3 Automatic Reclosing Circuit Breaker (ARCB)

Another improvement envisaged by the Project is to install ARCB, which is an equipment to reconnect the distribution line at the time of electrical faults. At present, BPC has installed 26 nos. of ARCB at different locations in the country. Given the rapid expansion of the rural distribution network, human intervention based responses are limited in shortening and area-wise limitation of blackouts.

The purpose of ARCB installation is to improve the power supply reliability, and BPC installs

ARCB under the following conditions.

- ✓ Based on the terrain through which line passes. If the line passes through thickly forested area, BPC installs such equipment to clear the transient faults.
- ✓ If the line is very long, ARCBs are installed to clear the downstream faults.
- ✓ Based on the type of feeder. If the feeder is getting T-off from urban line, then ARCBs are installed to segregate rural and urban faults for better reliability.
- ✓ In some places where ARCBs are allowed to install as an alternative measure for the construction of 33kV and 11kV substation and switching station, the installation of ARCBs helps to reduce the cost.

The Project requires 20 sets of 33 kV ARCB and 13 sets of 11 kV ARCB, these quantities are the request basis by ESD (Electricity Services Division).

The locations where ARCB will be installed may be indicated on the single line diagram by the respective ESD. The single line diagram is attached in Appendix-N.

4.4.4 Step Voltage Regulator (SVR)

In the radial MV distribution system, it is often necessary to regulate the feeder voltage by means of step voltage regulator.

Step-voltage regulators can be either (1) station-type, which can be single- or three-phase, and which can be used in substations for bus voltage regulation or individual feeder voltage regulation, or (2) distribution-type, which can be only single-phase and used pole-mounted out on overhead MV feeders.

The step-voltage regulator basically is an autotransformer which has numerous taps in the series winding. Taps are charged automatically under load by switching mechanism which responds to a voltage-sensing control in order to maintain voltage as close as practicable to a predetermined level. The voltage-sensing control receives its inputs from potential and current transformers and provides control of system voltage level and band width. In addition, it provides features such as operation counter, time-delay selection, test terminal, and control switch.

In case of MV lines of BPC, the feeder length sometimes reaches to eighty (80) km, it is difficult to maintain the feeder voltage to an allowable level, and the installation of distribution-type may be the option to improve the consumer end voltage.

4.5 Assessment of Project Scope

4.5.1 Project Consistency with Rural Electrification Master Plan

The JICA Master Plan provided a foundation for RE to a year when an overall grid extension reached 94% of all the households. The extent of on-grid villages was determined using an economic model designed to take into account the linkage of the network and the cumulative net benefits to the sub-feeder or feeder. A total of 1,716 villages were evaluated in which 1,268 villages were designated as on-grid.

BPC basically designed the last RE package surveys based on the results of REMP, especially on the on-grid designated feeders. However sometimes, there were strong local requests for inclusion of additional villages into the grid connection. The surveyors included the additional villages. Within the next JICA-designated dzongkhags, there are 240 villages designated as “off-grid” by REMP. However, 55 villages are now converted to “on-grid" status. Most of the converted villages have high investments at above USD 8,000 per customer..

Table-4.5.1 Changes of Planning Status of Master Plan Off-Grid Villages

		Off -> Off	Off -> ON	Total
1	Chukha	28	0	28
2	Dagana	16	2	18
3	Haa	0	5	5
4	Paro	10	1	11
5	Pemagatsel	5	2	7
6	Punakha	15	3	18
7	Samtse	8	13	21
8	Sarpang	27	13	40
9	Thimphu	15	0	15
10	Trongsa	4	0	4
11	Tsirang	10	6	16
12	Wangdue	47	10	57
	Total	185	55	240

(Prepared by JPST)

4.5.2 Collaboration with Other Donors

The RGoB is promoting the RE program aiming at “Electricity for All” by 2013. The following projects are planned to be implemented to achieve the goal in 2013 in parallel with JICA RE-2 project.

After the discussion between the concerned parties, the final set of RE were divided by two major lenders, namely JICA and ADB. ADB has assumed the Project work for the eastern dzongkhags as mentioned below, while JICA has assumed the responsibilities for the western dzongkhags. The Austrian Government has taken Gasa’s RE. The shares of the Project scope between the three lending agencies are shown in Table-4.5.2.

1) ADB RE-5 Project

ADB RE-5 will cover six dzongkhags (Lhuentse, Mongar, Samdrup Jongkhar, Trashigang, Trashiyangtse and Zhemgang).

2) ADA

Austrian Development Agency (ADA) will cover Gasa dzongkhag.

Table-4.5.2 Summary of Next Rural Electrification Projects by Donors

	Total Consumer	MV Length (km)	LV length (km)
Japan	3,701	566	447
ADB	5,075	545	404
Austria	229	31	5
Total	9,005	1,007	762

Source: BPC, ADB

4.5.3 Qualification as CDM Project

In conclusion, carbon reduction by the rural electrification project is too small to qualify for CDM project. The Project is estimated to contribute to the reduction of 3 liter of kerosene per household per month and 240 kg of firewood per month per household. With regard to forestry biomass, since biomass energy is defined as “carbon neutral”, the reduction of firewood consumption does not lead to green house gas (GHG) emission reductions. In addition, only afforestation/reforestation is considered to qualify for current CDM and avoided deforestation was excluded from the CDM in the first Kyoto commitment period. The remaining contributor is kerosene. With a total number of household of 3,701 and the emission coefficient of 2.53 kg per liter of kerosene, the estimated annual emission reduction is 337 tons of carbon dioxide. Given the current market value for the emission right of USD 17/ton, the annual valuation of carbon dioxide reduction is USD 5,730.

4.5.4 MV Route Revision

(1) Road Data

Based on the GIS data provided through the local consultant (Appendix B), the Study Team has reviewed the MV route data to find some gaps between the two routes. MV and road alignments are often planned from different perspective. While road planning need not to incorporate any MV routes in its planning, the existence of roads affect the MV planning in several aspects.

- MV alignment in proximity to roads is likely to reduce the operation and maintenance costs dramatically, and

- If the road is constructed prior to the construction of MV line, the civil costs of the MV line will decline dramatically.

On the other hand, the road alignment needs to maintain a certain grade to enable vehicle passage, thus it is much lengthier than the desirable MV alignment at a steep graded slope.

(2) MV Route Revision

The Study Team has revised all the proposed MV routes on GIS and Google Earth basis while maintaining 1) proximity to road network and 2) maintaining the minimum distance of alignments. In some cases in Sarpang, the MV routes were shifted uphill from the currently planned valley routes to follow road alignments also to shield the MV lines from potential flood damages. In other cases, re-routing was a matter of changing the sequence of connecting different villages by following road patterns. Obviously the original MV routes were planned without any regard to road planning. In such cases re-routing the MV alignments does not lead to increases in route length because there are many variations to connecting multiple nodes. Rerouting should be considered for each sub-feeder without falling into a trap of binary choice of not doing or doing. In some case it is a matter of small change while others are not. Given the enormous work required for construction and maintenance afterwards, it is suggested that the due attention should be paid for careful planning for each specific case. Our revised MV routes have been summarized and submitted to BPC and DOE in the form of GIS.

(3) MV Quantities

As a result of the MV revision, the total quantity requirement for MV lines has to be increased. Based on the comparison with the current planned quantities and additional length requirement, the buffer factors were adopted as shown in Table-4.5.3 to account for the revision requirement during the detail design and implementation to take the road network pattern into the alignments.

Table-4.5.3 Buffer factors

Chukha	1.15
Dagana	1
Haa	1
Paro	1
Pemagatshel	1
Punakha	1.1
Samtse	1.1
Sarpang	1.15
Trongsa	1
Tsirang	1.1
Wangdue	1

Prepared by JPST

4.5.5 Human Transport of Materials: Headloading

(1) Road Sector Survey

As shown in Appendix- B, JPST has commissioned a local consultant to obtain the latest road information on the existing and proposed roads. It was made possible to overlay the road data onto the MV GIS layers after geo-referencing to the right projection.

(2) Headloading Distance

Based on the GIS data of the roads, it was possible to make a headloading route plan for each substation on the map. As a result, the average headloading distance by dzongkhag was calculated as follows;

Table-4.5.4 Average Headloading Distance to Villages by Dzongkhag

	Average Headloading Distance to Village
Chukha	13.2
Dagana	6.8
Haa	30.3
Paro	4.0
Pemagatshel	12.2
Punakha	2.2
Samtse	8.3
Sarpang	26.6
Trongsa	4.1
Tsirang	6.3
Wangdue	6.5
ADB RE-5*	6.2

Note: ADB RE-5 calculated weighted average distance by physical weight.
Source: JPST

4.5.6 Assessment Result of Project Scope

(1) Grid Extension Work

In total, there are 317 substations (pole-mounted transformers) to be covered for the Project.Each substation serves either a part of or the entire village. The MV lines are 566 km in distance and LV lines are 447 km. The total number of customers covered is 3,701, in which 3,338 are domestic customers. The average number of customers per substation is 11.7. The maximum per substation is 41 customers, while the minimum is 2 customers.

Table-4.5.5 shows a summary of conductor lengths as categorized in terms of MV levels and phases. Single phase lines have a larger share than three phase lines since a large portion of lines are comprised of the last segment to the settlements.

Table-4.5.6 shows a summary of transformer types and their numbers. The most widely adopted transformers are 25 kVA in capacity for both 33 kV and 11 kV. The three phase transformers exceed the single phase transformers slightly.

Table-4.5.5 Medium Voltage Line Length by Voltage and Phase

Unit: km

Dzongkhag	33kV			11kV			Grand Total
	3 Phase	1 Phase	Total	3 Phase	1 Phase	Total	
Chukha	67.5	38.8	106.3	8.0	6.8	14.8	121.1
Dagana	47.2	30.0	77.2			0.0	77.2
Haa	14.2	14.4	28.6			0.0	28.6
Paro	1.6		1.6	5.5		5.5	7.1
Pemagatshel	10.0	11.0	21.0			0.0	21.0
Punakha		6.6	6.6	3.9		3.9	10.5
Samtse	40.4	2.5	42.9	39.3	17.7	57.0	100.0
Sarpang			0.0	100.9	18.1	119.0	119.0
Trongsa	30.0	5.6	35.7			0.0	35.7
Tsirang	6.6	8.0	14.6	5.9		5.9	20.6
Wangdue	8.0		8.0	17.3		17.3	25.3
Total	225.5	117.0	342.5	180.8	42.6	223.5	566.0

(Prepared by JPST)

Table-4.5.6 Transformer Requirements by Voltage, Phase and Capacity

Unit: Nos

Transformer capacity (kVA)	33kV			11kV			Grand Total
	3 Phase	1 Phase	Total	3 Phase	1 Phase	Total	
10	8	18	26	7	17	24	50
16	13	32	45	34	8	42	87
25	99	11	110	54	4	58	168
63	8		8	4		4	12
Total	128	61	189	99	29	128	317

(Prepared by JPST)

CHAPTER 5 COST ESTIMATION FOR THE PROJECT

5.1 Grid Extension Cost

There are two aspects to cost estimation. Since the Project is comprised of a number of geographically discrete feeders and subfeeders, the cost of each subfeeder needs to be calculated. The costs of feeders can be combined in order to derive cost summaries per dzongkhag. Another combination is by contract packages. Since the BPC procures the materials directly, the contract packages need to be grouped according to vendor types such as electric poles, transformers, conductors, metal fittings manufacturers, civil work contractors and transporters.

The quantity and cost of material procured in the project is summarized by dzonkhags in Table-5.1.1 and Table-5.1.2. Within these dzongkhags, there were 71 feeder lines which extend 566 km of MV lines and 447 km of LV lines as shown in Table-5.1.1. The feeders are expected to supply electricity to 3,701 customers in total. The total Project cost is estimated to be JPY 2,713 million (USD 30.9 million) out of which JPY 1,867 million (USD 21.3 million) is required for the procurement of materials and construction as the base-cost for JICA financing shown in Table-5.1.3). The detail of the project cost is shown in Appendix-R. The remainder is required for transportation by vehicles and human workers, as well as erection. The average cost per customer is estimated at JPY 460,688 (USD 5,253). The high cost requirement arises from two major factors. Since the remaining electrification targets are located in less densely-populated and far areas, the line length are much longer and each substation (transformer) supplies less number of customers. In the case of the JICA RE-2 Project, the average MV line length is 152 m per customer while that for the JICA RE-1 Project is 60 m per customer. The adoption of new poles has also led to an increase in unit material cost per length.

Table-5.1.1 Project Quantity Summary by Dzonkhags

Dzongkhag	Nos. of Total consumer (household and institute)	MV length (km)	LV length (km)	Nos. of substation	Nos. of ARCB	Lightning damage prevention		Average headloading distance to village (km)
						Shield wire (km)	Nos. of Couter-poise	
Chukha	629	121.1	68.4	59	33	290	700	13.2
Dagana	416	77.2	61.8	35				6.8
Haa	99	28.6	8.4	11				30.3
Paro	43	7.1	1.5	2				4.0
Pemagatshel	168	21.0	17.2	11				12.2
Punakha	49	10.5	6.1	5				2.2
Samtse	988	100.0	121.8	82				8.3
Sarpang	730	119.0	99.3	65				26.6
Trongsa	321	35.7	28.6	22				4.1
Tsirang	93	20.6	22.9	9				6.3
Wangdue	165	25.3	11.4	16				6.5
Total	**3,701**	**566.0**	**447.4**	**317**	**33**	**290**	**700**	

(Prepared by JPST)

Table-5.1.2 Project Cost Summary by Dzonkhags

		Material cost (Million JPY)	Erection cost (Million JPY)	Headloading cost (Million JPY)	Transportation cost (Million JPY)	Total cost (Million JPY)	Total cost (Million USD)
Distribution lines	Chukha	204.7	29.1	75.7	3.2	312.9	3.6
	Dagana	152.2	19.7	29.2	3.0	204.1	2.3
	Haa	39.7	6.5	33.2	1.7	81.0	0.9
	Paro	9.7	1.3	1.1	0.3	12.4	0.1
	Pemagatshel	39.2	5.5	13.5	0.7	59.0	0.7
	Punakha	16.5	2.1	1.2	0.8	20.6	0.2
	Samtse	245.2	32.1	56.1	2.4	335.8	3.8
	Sarpang	244.1	37.7	174.9	6.7	463.4	5.3
	Trongsa	72.5	9.2	8.7	2.4	92.8	1.1
	Tsirang	42.7	5.6	7.6	0.8	56.6	0.6
	Wangdue	49.4	6.2	8.7	2.4	66.6	0.8
Other items	ARCB	89.2		29.4	3.6	122.2	1.4
	Shield wire	23.7		7.8	0.9	32.5	0.4
	Counter-poise	5.2		1.7	0.2	7.1	0.1
	Total	**1,233.9**	**193.9**	**410.0**	**29.1**	**1,867.0**	**21.3**

(Prepared by JPST)

Table-5.1.3 Grid Extension Project Cost

Annual Fund Requirement

Base Year for Cost Estimation:	Nov, 2010		
Exchange Rates	Nu = Yen		1.88
Price Escalation:	FC:	1.8%	LC: 2.4%
Physical Contingency	10%		
Physical Contingency for Consultant	10%		

	Item	Total				
		FC (Million JPY)	LC (Million BTN)	Total (Million JPY)	Total (Million USD)	Percentage to grand total
A. ELIGIBLE PORTION						
Ⅰ)	Procurement / Construction	1,348	395	2,091	23.8	76.2%
	1. Substation and Line Materials	1,212	12	1,234	14.1	45.0%
	2. Transportation Cost	0	15	29	0.3	1.1%
	3. Erection Cost	0	321	604	6.9	22.0%
	Base cost for JICA financing	1,212	348	1,867	21.3	68.0%
	Price escalation	13	11	34	0.4	1.2%
	Physical contingency	123	36	190	2.2	6.9%
Ⅱ)	Consulting services	38	3	43	0.5	1.6%
	Base cost	34	2	38	0.4	1.4%
	Price escalation	1	0	1	0.01	0.0%
	Physical contingency	3	0	4	0.05	0.1%
Total (Ⅰ + Ⅱ)		1,386	398	2,134	24.3	77.8%
B. NON ELIGIBLE PORTION						
a	Procurement / Construction	0	51	97	1.1	3.5%
	5. Compensation including the removal of orchard trees	0	40	76	0.9	2.8%
	6. Envirenmental Monitoring	0	5	10	0.1	0.4%
	Base cost for RGoB financing	0	46	86	1.0	3.1%
	Price escalation	0	1	2	0.02	0.1%
	Physical contingency	0	5	9	0.1	0.3%
b	Land Acquisition	0	0	0	0.0	0.0%
	Base cost	0	0	0	0.0	0.0%
	Price escalation	0	0	0	0.0	0.0%
	Physical contingency	0	0	0	0.0	0.0%
c	Administration cost	0	119	223	2.5	8.1%
d	BIT (local)	0	8	15	0.2	0.5%
e	BIT (foreign)	0	1	1	0.01	0.0%
f	Duties and Sales Tax	0	129	242	2.8	8.8%
Total (a+b+c+d+e+f)		0	308	578	6.6	21.1%
TOTAL (A+B)		1,386	706	2,713	30.9	98.9%
C. Interest during Construction		25	0	25	0.3	0.9%
	Interest during Construction(Const.)	25	0	25	0.3	0.9%
	Interest during Construction (Consul.)	0	0	0	0.0	0.0%
D. Commitment Charge		6	0	6	0.1	0.2%
GRAND TOTAL (A+B+C+D)		1,417	706	2,744	31.3	100.0%
E. JICA finance portion incl. IDC (A + C + D)		1,417	398	2,166	24.7	78.9%

Note Administration cost =10%

(Prepared by JPST)

5.2 Grid Extension Cost Estimation Methodology

The overall unit costs for materials, civil and transport costs are summarized at the end of this section in Table-5.2.9.

5.2.1 Unit Cost

BPC has a well-established system of cost estimation for the power distribution network. The system has been effective for all the past rural electrification projects. They have developed cost estimation templates using Excel for each type of MV conductor, transformer, LV, etc. The templates enable the planner to obtain the total line construction cost for a particular distance by simply inserting a distance value at the top cell. The total cost includes poles, steel fittings, and accessories as well as cement, paint and wires. As shown in Table-5.2.1, the template covers the entire requirement of materials and parts of the construction of MV conductors. The same system is adopted for cost estimation of transformers, which includes the cost of double poles for mounting the transformers (as shown in Table-5.2.2).

The unit costs used for cost estimation of each sub-feeder are based on the data provided by BPC. The unit cost of each material is based on actual contract prices executed at the time of ADB Rural Electrification IV and JICA-Phase I Project. Most of the tenders were executed during 2007-2008. To update prices except for telescopic poles, a uniform 15% increase is applied to every item[1]. Although the unit costs need to be re-bundled into vendor based contract packages for poles, steel fittings, conductors, etc., this method of lump sum unit cost makes it easy to estimate the project costs based on the distance of MV and LV and transformer requirements.

ADB and RGoB have discussed and agreed to the adoption of telescopic poles to ease manual transport of poles through the difficult terrain of the next rural electrification sites. However, telescopic poles will increase the unit material cost of conductor construction.

[1] The unit prices are based on the actual procurement prices in 2008. 15% is the increase adopted to adjust these prices to the current prices agreed upon between ADB and BPC.

Table-5.2.1 Unit Cost Breakdown of Conductor

Bill of Materials for 33 kV single circuit line (3 Φ) with RABBIT conductor
Length of line : 1.000 km

Sl.#	Description of items	Unit	Total quantity	Unit cost (Nu.)	Total cost (Nu.)
I	**Foreign Materials**				
1	Steel telescopic poles 11 mtr. long with base plate, fixing bolts, etc.	No.	16	18,254.70	292,075.20
2	33 kV single pole cross arm assembly complete with M&U clamps, nuts, bolts and other accessories.	Set	4	967.50	3,869.98
3	33 kV top hamper assembly complete with M&U clamps, nuts, bolts and other accessories.	Set	4	515.10	2,060.39
4	33 kV cross arm assembly for H-frame (O) complete with M clamps, nuts, bolts and other accessories.	Set	6	3,965.11	23,790.65
5	33 kV cross brace arm assembly for H-frame with full clamps, nuts, bolts and other accessories.	Set	6	2,837.63	17,025.75
6	G.I. stay set assembly (1 no. turn buckle, 1 no. stay rod with base plate)	Set	10	1,154.60	11,546.00
7	33 kV stay insulator	No.	10	89.72	897.23
8	G.I. stay wire 7/8 GSW	kg	120	79.99	9,599.28
9	Stay clamp assembly, 33 kV	Set	10	283.22	2,832.22
10	Polymer Strain Insulator 33kV	Set	36	1,323.68	47,652.64
11	33 kV pin insulator assembly with pin	Set	12	787.51	9,450.10
12	Preform dead end terminations - RABBIT	No.	36	50.27	1,809.59
13	Tension joints - RABBIT	No.	9	125.40	1,128.56
14	ACSR conductor - RABBIT	km	3.100	30,430.15	94,333.47
15	P.G. clamp for RABBIT	No.	18	43.24	778.32
16	Spike earthing set 2500x20 mm complete with connecting plates, nuts & bolts with 4 metre G.I. wire 8 GSW .	Set	16	450.24	7,203.78
17	Barbed wire	kg	200	79.99	15,998.80
18	Danger plate (enamelled) 33 kV	No.	10	141.61	1,416.11
19	Bituminous aluminium paint	Ltr.	0	136.85	0.00
20	Bituminous black paint	Ltr.	20	73.95	1,478.90
21	Miscellaneous items (1% on above)				5,449.47
Foreign material cost (Nu.)					**550,396.44**
II	**Local Materials**				
21	Cement	MT	1.3	3,956.00	5,142.80
22	Sand	Cft	42	23.00	966.00
23	Stone chips 20 mm aggregate	Cft	94	23.00	2,162.00
24	Boulder for double pole bonding	Cft	94	57.50	5,405.00
Local material cost (Nu.)					**6,108.80**
Total material cost (Nu.)					**556,505.24**

Note: The values in green and blue cells are derived from the unit cost used in ADB RE-4 and JICA RE-1 respectively

Source: BPC

Table-5.2.2 Unit Cost Breakdown of Transformer

Bill of Materials for 33/0.240 kV, 16 kVA substation

Number of transformer (1 Φ) : 1

Sl.#	Particulars	Unit	Total quantity	Unit cost (Nu.)	Total cost (Nu.)
I	**Foreign Materials**				
1	Steel telescopic poles 11 mtr. long with base plate, fixing	No.	2	18,254.70	36,509.40
2	Substation cross arm (100x50x6 mm channel) complete with M clamps, nuts, bolts and other accessories.	Set	1	3,799.17	3,799.17
3	Polymer Strain Insulator 33kV	Set	4	1,323.68	5,294.74
4	Preform dead end terminations - RABBIT	No.	4	50.27	201.07
5	G.I. stay set assembly (1 no. turn buckle, 1 no. stay rod with base plate)	Set	2	1,154.60	2,309.20
6	G.I. stay wire 7/8 GSW	kg	15.00	79.99	1,199.91
7	33 kV stay insulator	No.	2	89.72	179.45
8	Stay clamp assembly, 33 kV	Set	2	283.22	566.44
9	33 kV pin insulator assembly with pin	Set	2	787.51	1,575.02
10	30 kV, 5 kA Lightning (Surge) arrestor complete set (gapless type) - set of 2	Set	1	6,215.75	6,215.75
11	Steel support for lightning arrester (75x40x6 channel) complete with clamps, nuts, bolts, etc.	Set	1	1,488.54	1,488.54
12	Single Phase Transformer 33/0.240 kV, 16 kVA	No.	1	108,624.29	108,624.29
13	Transformer mounting platform (125x65x6 channel) complete with M clamps, nuts, bolts and other accessories	Set	1	6,206.56	6,206.56
14	Single Phase LV Distribution Board 2 way 100 Amps. (bus rating) with 4 nos. 50 Amps. Fuses	No.	1	15,750.17	15,750.17
15	LV distribution pillar support (100x50x6 MS channel) complete with clamps, nuts, bolts, etc.	No.	1	3,514.87	3,514.87
16	33 kV DO fuse unit (1 set = 2 DO fuses)	Set	1	6,756.25	6,756.25
17	M.S. channel (75x40x6 mm) support for DO fuse complete with clamps, nuts, bolts, etc.	Set	2	4,232.66	8,465.31
18	ACSR conductor - RABBIT	km	0.010	30,430.15	304.30
19	P.G. clamp for RABBIT	No.	4	43.24	172.96
20	Terminal lugs - RABBIT	No.	8	21.08	168.64
21	Pipe earthing set, 2500 x 40mm	Set	2	1,115.59	2,231.18
22	Earthing conductor, G.I. strip 25x6 mm	Mtr.	72.00	74.05	5,331.49
23	2 core, 650/1100 volts, 70 mm^2 armoured PVC underground	Mtr.	5.00	341.60	1,707.98
24	Terminal lugs for 2 core, 70 mm2 underground cable	No.	4	20.00	79.99
25	2 core, 70 mm^2 underground cable glands	No.	2	83.78	167.56
26	LV ABC conductor, 2 core, 50 mm2	km	0.06	77,538.75	4,652.33
27	Terminal lugs for 2 core, 50 mm^2 LV ABC	No.	8	16.76	134.04
28	2 core, 50 mm^2 LV ABC glands	No.	2	78.37	156.75
29	Barbed wire	kg	12.5	79.99	999.93
30	Danger plate (enamelled) 33 kV	No.	1	141.61	141.61
31	Bituminous aluminium paint	Ltr.	0	136.85	0.00
32	Bituminous black paint	Ltr.	2.5	73.95	184.86
33	Miscellaneous items (1% of above)			0.00	2,250.90
Foreign material cost (Nu.)					**227,340.64**
II	**Local Materials**				
33	Cement	MT	0.100	3,956.00	395.60
34	Sand	Cft.	5	23.00	115.00
35	Stone chips 20 mm aggregate	Cft.	9	23.00	207.00
Local material cost (Nu.)					**510.60**
Total material cost (Nu.)					**227,851.24**

Note: The values in green and blue cells are derived from the unit cost used in ADB RE-4 and JICA RE-1 respectively

Source: BPC

5.2.2 Civil Cost Estimates

Civil costs are calculated as unit costs based on the civil contract cost analysis as shown in Table-5.2.3. The average rates are obtained from the actual contracts agreed upon for ADB RE-4 and JICA RE-1 and the ratio to material costs are obtained (Table5.2.3). For the tender of the civil contract, the price quotation is required for each type of work such as conductor but inclusive of local transport, manual transport after the road end to the project site, tree felling, erection, stringing etc.

Table-5.2.3 Civil Cost Analysis

No	Material	Total material cost (Nu)	Contractual Prices				Ratio of Contractual Pricdes to Total Material Cost			
			Civil Cost Ave (Nu)	**Civil Cost Standard Deviation (Nu)**	**Civil Cost Max (Nu)**	**Civil Cost Min (Nu)**	**Civil Cost Ave**	**Civil Cost S. Dev.**	**Civil Cost Max**	**Civil Cost Min**
1	33 kV-DOG (3P)	652,764	120,708	20,126	170,000	95,000	23%	4%	32%	18%
2	33 kV-RABBIT (3P)	556,505	128,389	28,139	185,000	85,000	29%	6%	42%	19%
3	33 kV-DOG (1P)	567,852	106,000	24,000	130,000	82,000	26%	6%	31%	20%
4	33 kV-RABBIT (1P)	503,582	128,068	26,023	175,000	85,000	36%	7%	49%	24%
5	11 kV-DOG (3P)	613,059	156,241	53,309	215,000	65,000	35%	12%	48%	15%
6	11 kV-RABBIT (3P)	516,800	136,882	43,111	210,000	65,000	37%	12%	57%	18%
7	11 kV-DOG (1P)	538,521	156,241	0	90,000	90,000	45%	0%	26%	26%
8	11 kV-RABBIT (1P)	474,251	136,882	25,884	175,000	105,000	47%	9%	60%	36%
9	LV ABC-4C-50 sq.mm-3P	411,353	94,976	24,154	165,000	60,000	33%	8%	57%	21%
10	LV ABC-2C-50 sq.mm-1P	336,001	90,661	25,637	165,000	50,000	40%	11%	73%	22%
11	LV ABC-4C-95 sq.mm-3P	529,642	102,201	27,905	155,000	60,000	25%	7%	37%	14%
12	LV ABC-2C-95 sq.mm-1P	388,140	93,110	24,275	155,000	55,000	34%	9%	56%	20%
13	33 kV-25 kVA (3P)	304,953	70,647	15,087	88,500	53,692	28%	6%	35%	21%
14	33 kV-63 kVA(3P)	330,967	80,245	40,483	150,000	40,000	44%	22%	82%	22%
15	33 kV-10 kVA (1P)	225,581	48,203	22,597	100,000	20,000	26%	12%	54%	11%
16	33 kV-16 kVA (1P)	227,851	53,893	21,853	100,000	23,000	29%	12%	54%	12%
17	33 kV-25 kVA (1P)	229,295	56,509	22,979	100,000	23,000	30%	12%	54%	12%
18	11 kV-63 kVA(3P)	311,763	81,514	35,831	150,000	45,000	32%	14%	59%	18%
19	11 kV-16 kVA (1P)	216,933	56,733	15,062	100,000	45,000	33%	9%	58%	26%
20	11 kV-25 kVA (1P)	217,465	66,882	23,673	100,000	40,000	33%	12%	49%	20%

Source: BPC RED, JPST Tabulation

In order to update civil costs to adequately cover the longer headloading distance over difficult terrains, the civil costs for conductor, ABS, service connection installation were increased by 50% whereas those for transformers were increased by 80% to account for the sheer mass of the equipment[2].

Transport work is defined as transport of materials from the main material store in Phuentsoling of BPC to local micro-stores. The work has been contracted to trucking companies independently. By analyzing past transport costs, BPC has derived transport cost ratios to the material for each dzongkhag.

5.2.3 Headloading Costs

It is not possible to break down the cost component such as headloading by type of work from the past contracts. However, the ratio of civil erection cost to the headloading cost is estimated to be 40 to 60 on the average. The contract price analysis includes the statistics such as standard

2 JPST and BPC discussed the appropriate rates of increase for civil cost. Given lack of reliable unit costs for headloading and road to site distances, these ratios were adopted as educated guess on the safer side.

deviation as well as averages. The adoption of telescopic poles has increased the unit cost of conductors. At the same time, it should contribute to lessening manual transport costs which are the largest cost components within the civil work. It is estimated that the telescopic pole should reduce the headloading costs by 10%.

Based on the headloading average distance of 6.2 km for the past ADB RE4, the civil cost multipliers has been derived based on the ratios of the estimated average headloading distances to villages as shown in Table-4.5.4 in the following formula;

Dzongkhag-wise Headloading Distance / ADB RE4 Average Distance ×0.9.

The civil cost multiplier for each dzongkhag is calculated as shown in Table-5.2.4.

Table-5.2.4 Civil Cost Multiplier by Dzongkhag

Civil Cost Multiplier	
Chukha	1.5
Dagana	1.0
Haa	3.0
Paro	0.7
Pemagatshel	1.5
Punakha	0.6
Samtse	1.1
Sarpang	2.7
Trongsa	0.8
Tsirang	0.9
Wangdue	1.0

Note: Multiplier is the factor to the standard civil costs

(Prepared by JPST)

5.2.4. Transport Costs

Transport work is defined as transport of materials from the main material store in Phuentsoling of BPC to local micro-stores. The work has been contracted to trucking companies independently. By analyzing past transport costs, BPC has derived transport cost ratios to the material for each dzongkhag.

5.2.5 Telescopic Pole Costs

As far as the material costs for the newly adopted telescopic poles, it is about Nu. 50,000 more expensive than the conventional tubular poles as shown in the comparison of Table-4.3.2 and 4.3.3. However, it is expected that telescopic poles do reduce the headloading cost portion with the civil costs. The headloading costs depend on the distance of the headloading itself as discussed above. In the case of Haa, it is estimated that the saving on headloading costs offsets the increases in the unit costs for telescopic poles. However, in other dzongkhags, it is estimated that the reduction in headloading costs does not lead to the reduction in the overall costs

Table-5.2.5 shows the cost comparison between telescopic poles and tubular poles in the case of 33kV dog conductors. The total cost depends on the distance for headloading which varies from location to location.

Below 15 km, basically the total costs for tubular poles are less due to its lower prices in the original material costs. However, beyond 15 km of headloading, the advantage of telescopic poles is clear. In the next rural electrification under JICA, the feeders in Sarpang and Haa have the headloading distances beyond 20 km, clearly indicating the advantage for the telescopic poles.

Table-5.2.5 Cost Comparison of Telescopic and Tubular in Total Cost

		Telescopic Poles	Tubular Poles	Difference
Material Costs		660,331	609,834	(50,498)
Transport Costs		15,320	14,148	(1,172)
Erection Costs		74,989	74,989	-
Headloading Costs	Distance			
	1 km	14,421	18,026	3,605
	5km	72,105	90,131	18,026
	10km	144,209	180,261	36,052
	15km	216,314	270,392	54,078
	20km	288,418	360,523	72,105
	25km	360,523	450,653	90,131
	30km	432,627	540,784	108,157
Total Cost	Distance			
	1 km	765,061	716,997	(48,064)
	5km	822,744	789,101	(33,643)
	10km	894,849	879,232	(15,617)
	15km	966,953	969,362	2,409
	20km	1,039,058	1,059,493	20,435
	25km	1,111,162	1,149,624	38,461
	30km	1,183,267	1,239,755	56,488

Note: transport cost assumes 2.3% of the material cost. Headloading cost for telescopic poles is estimated to be 80% of the tubular cost in headloading.

(Prepared by JPST)

Another advantage of telescopic pole is no need of the anticorrosive treatment after erection since telescopic poles are hot-dipped galvanized. The cost comparison in Table-5.2.6, 5.2.7 and 5.2.8 considers the cost of the anticorrosive treatment for tubular poles.

The total cost of MV and LV lines with telescopic poles is less than those with tubular poles as shown in Table-5.2.6

Table-5.2.6 Summary of the Total Cost Comparison between Telescopic and Tubular Poles

Unit: USD

(1) Total cost of MV and LV line with telescopic pole	16,124,094
(2) Total cost of MV and LV line with tubular pole	18,789,390
(1)/(2)	85.8%
Difference between (1) and (2)	2,665,295

(Prepared by JPST)

Table-5.2.7 Total Cost of MV line with Telescopic and Tubular Poles

Dzonkhag	(A) Average Headloading Distance to Village (km)	(B) Standard Erection Cost (including headloading cost)	Telescopic pole				Tubular pole				
			Material Cost	Erection Cost (excluding headloading cost)	(C) Headloading Cost	Tranportaion Cost	Material Cost	Erection Cost (Headloading cost is excluded)	(D) Headloading Cost	Tranportaion Cost	Anticorrosive Treatment Cost
Chukha	13.2	574,582	1,332,985	183,866	523,649	21,759	1,292,888	183,866	654,561	29,736	421,664
Dagana	6.8	339,063	889,546	120,556	178,093	18,197	858,456	120,556	222,617	19,744	268,985
Haa	30.3	117,865	303,701	41,908	274,902	12,653	296,617	41,908	343,628	6,822	99,513
Paro	4.0	30,589	75,952	10,876	9,377	3,031	71,899	10,876	11,721	1,654	24,818
Pemagatshel	12.2	86,800	223,984	30,862	81,608	4,226	217,216	30,862	102,010	4,996	73,077
Punakha	2.2	42,863	107,416	15,240	7,380	5,057	102,762	15,240	9,225	2,364	36,621
Samtse	8.3	430,354	1,088,899	153,015	274,959	11,580	1,040,753	153,015	343,699	23,937	348,224
Sarpang	26.6	535,223	1,413,300	190,302	1,096,779	41,865	1,221,036	190,302	1,370,974	28,084	414,568
Trongsa	4.1	151,129	394,670	53,735	47,311	14,221	386,018	53,735	59,139	8,878	124,271
Tsirang	6.3	87,308	223,501	31,043	42,222	4,378	209,160	31,043	52,778	4,811	71,590
Wangdue	6.5	125,548	345,181	44,639	62,365	17,054	281,010	44,639	77,956	6,463	88,085
Total		2,521,324	6,399,136	876,041	2,598,646	154,022	5,977,815	876,041	3,248,308	137,490	1,971,416
Grand total			10,027,845				12,211,069				
Difference			2,183,224								

Note: It is assumed that eight days work by three workers for one km of MV line is required for the anticorrosive treatment, and the treatment is required every eight years during thirty years of the lifetime.

(Prepared by JPST)

Table-5.2.8 Total Cost of LV line with Telescopic and Tubular Poles

Dzonkhag	(A) Average Headloading Distance to Village (km)	(B) Standard Erection Cost (including headloading cost)	Telescopic pole				Tubular pole				
			Material Cost	Erection Cost (excluding headloading cost)	(C) Headloading Cost	Tranportaion Cost	Material Cost	Erection Cost (Headloading cost is excluded)	(D) Headloading Cost	Tranportaion Cost	Anticorrosive Treatment Cost
Chukha	13.2	209,745	617,864	74,576	212,392	8,698	413,775	74,576	265,490	9,517	234,235
Dagana	6.8	193,297	596,683	68,728	101,530	10,861	395,076	68,728	126,912	9,087	211,550
Haa	30.3	26,274	81,794	9,342	61,281	3,098	54,049	9,342	76,602	1,243	28,647
Paro	4.0	4,455	12,914	1,584	1,366	362	8,683	1,584	1,707	200	5,009
Pemagatshel	12.2	52,363	152,285	18,618	49,231	2,581	102,309	18,618	61,538	2,353	58,788
Punakha	2.2	18,391	50,933	6,539	3,166	2,067	34,646	6,539	3,958	797	21,051
Samtse	8.3	377,701	1,143,322	134,294	241,318	9,449	760,586	134,294	301,648	17,493	416,942
Sarpang	26.6	306,980	922,199	109,149	629,063	20,066	614,621	109,149	786,329	14,136	339,990
Trongsa	4.1	87,653	257,578	31,166	27,440	7,787	172,601	31,166	34,300	3,970	97,988
Tsirang	6.3	69,832	203,874	24,829	33,771	3,220	136,836	24,829	42,214	3,147	78,277
Wangdue	6.5	36,135	113,815	12,848	17,950	4,620	75,000	12,848	22,437	1,725	39,188
Total		1,382,828	4,153,259	491,672	1,378,508	72,810	2,768,181	491,672	1,723,136	63,668	1,531,664
Grand total			6,096,249				6,578,320				
Difference			482,071								

Note: It is assumed that eight days work by three workers for one km of MV line is required for the anticorrosive treatment, and the treatment is required every eight years during thirty years of the lifetime.

(Prepared by JPST)

In Table-5.2.7 and 5.2.8, the head loading cost is derived from following formula;

Headloading cost of tubular pole (C) = (A) Average / 6.2km (Average distance in ADB RE-4) x (B) x0.6

Headloading cost of telescopic pole (D) = (C) x 0.8

Table-5.2.9 List of Unit Prices by Material Unit

	Material Cost			Civil Cost	Dzongkhag-wise Transportation Cost from Phuentseling to Regional Storage																		
Type of Material	Foreign Material Cost (US$)	Local material cost (US$)	Total Material Cost (US$)	Civil Costs (US$)	Chukha	Dagana	Gasa	Haa	Lhuntse	Mongar	Paro	Pemagatshel	Punakha	Samdrup jongkhar	Samtse	Sarpang	Tashigang	Thimphu	Trashiyangtse	Trongsa	Tsirang	Wangdue	Zhemgang
Bare Conductor Lines																							
33 kV-DOG (3P)	13,877	293	14,008	4,166	1.50%	1.93%	5.04%	4.03%	4.88%	4.88%	2.98%	1.81%	4.32%	4.25%	0.88%	2.32%	4.57%	3.49%	1.99%	3.21%	1.68%	4.32%	2.40%
33 kV-RABBIT (3P)	11,811	131	11,942	3,650	1.73%	2.23%	5.81%	4.64%	5.62%	5.62%	3.43%	2.08%	4.97%	4.90%	1.02%	2.67%	5.31%	4.02%	2.29%	3.71%	1.94%	4.97%	2.77%
33 kV-DOG (1P)	12,072	261	12,186	3,898	1.25%	1.61%	4.21%	3.36%	4.07%	4.07%	2.49%	1.51%	3.61%	3.55%	0.74%	1.94%	2.72%	2.91%	1.66%	2.69%	1.40%	3.61%	2.01%
33 kV-RABBIT (1P)	10,692	114	10,806	3,415	1.43%	1.84%	4.79%	3.83%	4.64%	4.64%	3.83%	1.72%	4.11%	4.05%	0.84%	2.21%	3.09%	3.32%	1.89%	3.06%	1.60%	4.11%	2.29%
11 kV-DOG (3P)	13,025	131	13,156	4,166	1.64%	2.11%	5.51%	4.40%	5.33%	5.33%	3.26%	1.81%	4.72%	4.65%	0.97%	2.53%	5.32%	3.81%	2.17%	3.51%	1.84%	4.72%	2.63%
11 kV-RABBIT (3P)	10,959	131	11,090	3,650	1.92%	2.47%	6.44%	5.15%	6.23%	6.23%	3.81%	2.31%	5.52%	5.43%	1.13%	2.96%	6.59%	4.45%	2.54%	4.11%	2.15%	5.52%	3.07%
11 kV-DOG (1P)	11,442	114	11,556	3,898	1.54%	1.98%	5.17%	4.13%	5.00%	5.00%	3.06%	1.85%	4.43%	4.37%	0.91%	2.38%	3.34%	3.58%	2.04%	3.30%	1.72%	4.43%	2.47%
11 kV-RABBIT (1P)	10,063	114	10,177	3,415	1.81%	2.33%	6.07%	4.85%	5.87%	5.87%	3.59%	2.18%	5.20%	5.12%	1.06%	2.79%	5.32%	4.20%	2.39%	3.87%	2.02%	5.20%	2.89%
Covered Conductor Lines																							
33 kV-AAAC (3P 120 sq.mm)	16,533	131	16,664	4,583	1.50%	1.93%	5.04%	4.03%	4.88%	4.88%	2.98%	1.81%	4.32%	4.25%	0.88%	2.32%	4.57%	3.49%	1.99%	3.21%	1.68%	4.32%	2.40%
33 kV-AAAC (3P 80 sq.mm)	14,494	134	14,627	4,015	1.73%	2.23%	5.81%	4.64%	5.62%	5.62%	3.43%	2.08%	4.97%	4.90%	1.02%	2.67%	3.31%	4.02%	2.29%	3.71%	1.94%	4.97%	2.77%
33 kV-AAAC (1P 120 sq.mm)	14,387	114	14,501	4,288	1.25%	1.61%	4.21%	3.36%	4.07%	4.07%	3.36%	1.51%	3.61%	3.55%	0.74%	1.94%	2.72%	2.91%	1.66%	2.69%	1.40%	3.61%	2.01%
33 kV-AAAC (1P 80 sq.mm)	13,026	114	13,140	3,757	1.43%	1.84%	4.79%	3.83%	4.64%	4.64%	3.83%	1.72%	4.11%	4.05%	0.84%	2.21%	3.09%	3.32%	1.89%	3.06%	1.60%	4.11%	2.29%
11 kV-AAAC (3P 120 sqmm)	15,571	134	15,704	4,583	1.64%	2.11%	5.51%	4.40%	5.33%	5.33%	3.26%	1.81%	4.72%	4.65%	0.97%	2.53%	5.32%	3.81%	2.17%	3.51%	1.84%	4.72%	2.63%
11 kV-AAAC (3P 80 sqmm)	15,507	134	15,641	4,015	1.92%	2.47%	6.44%	5.15%	5.00%	6.23%	3.81%	2.31%	5.20%	5.53%	1.13%	2.96%	6.59%	4.45%	2.54%	4.11%	2.15%	5.20%	3.07%
11 kV-AAAC (1P 120 sqmm)	13,668	114	13,783	4,288	1.54%	1.98%	5.17%	4.13%	5.00%	5.00%	3.06%	1.85%	4.43%	4.37%	0.91%	2.38%	3.34%	3.58%	2.04%	3.30%	1.72%	4.43%	2.47%
11 kV-AAAC (1P 80 sqmm)	12,217	114	12,332	3,757	1.81%	0.00%	6.07%	4.85%	5.87%	5.87%	3.59%	2.18%	5.52%	5.12%	1.06%	2.79%	5.32%	4.20%	2.39%	3.87%	2.02%	5.52%	2.89%
ABS																							
ABS-33kV	890	0	890	2,533	1.25%	1.61%	5.04%	4.03%	4.07%	3.16%	1.93%	1.51%	3.61%	3.55%	0.57%	1.94%	2.72%	3.49%	1.66%	2.08%	1.40%	3.61%	2.40%
ABS-11kV	686	0	686	2,418	1.54%	1.81%	5.51%	4.40%	4.58%	3.69%	2.26%	1.70%	4.05%	3.99%	0.67%	2.18%	3.34%	3.81%	1.87%	2.43%	1.58%	4.05%	2.63%
LV																							
LV ABC-50 sq.mm (4)	11,233	133	11,366	2,725	1.35%	1.74%	4.53%	3.62%	4.38%	4.38%	2.68%	1.62%	3.88%	3.82%	0.79%	2.08%	4.71%	3.13%	1.78%	2.89%	1.51%	3.88%	2.16%
LV ABC-50 sq.mm (2)	8,197	133	8,329	2,483	1.35%	1.74%	4.53%	3.62%	4.38%	4.38%	2.68%	1.62%	3.88%	3.82%	0.79%	2.08%	4.71%	3.13%	1.78%	2.89%	1.51%	3.88%	2.16%
Bare Conductor Line Transformers																							
33 kV-25 kVA (3P)	6,533	11	6,544	1,884	1.42%	1.84%	4.79%	3.83%	4.64%	4.64%	2.83%	1.72%	4.10%	4.04%	0.84%	2.20%	1.67%	3.31%	1.89%	3.06%	1.60%	4.10%	2.28%
33 kV-63 kVA(3P)	7,091	11	7,102	2,140	1.10%	1.41%	3.68%	2.94%	3.56%	3.56%	2.18%	1.32%	3.15%	3.11%	0.65%	1.69%	2.29%	2.55%	1.45%	2.35%	1.23%	3.15%	1.76%
33 kV-10 kVA (1P)	4,830	11	4,841	1,285	2.13%	2.74%	7.15%	5.71%	6.92%	6.92%	4.23%	2.56%	6.12%	6.03%	1.25%	3.29%	2.66%	4.95%	2.82%	4.56%	2.38%	6.12%	3.41%
33 kV-16 kVA (1P)	4,879	11	4,890	1,437	1.93%	2.49%	6.48%	5.18%	6.28%	6.28%	3.84%	2.32%	5.56%	5.47%	1.14%	2.98%	3.30%	4.49%	2.56%	4.14%	2.16%	5.56%	3.09%
33 kV-25 kVA (1P)	4,910	11	4,920	1,507	1.64%	2.11%	5.50%	4.40%	5.33%	5.33%	3.25%	1.97%	4.71%	4.65%	0.97%	2.53%	4.71%	3.31%	2.17%	3.51%	1.83%	4.71%	2.62%
11 kV-16 kVA (3P)	6,058	11	6,069	1,285	2.05%	2.64%	6.89%	5.51%	6.67%	6.67%	4.07%	2.47%	5.90%	5.81%	1.21%	3.17%	1.67%	4.76%	2.72%	4.39%	2.30%	5.90%	3.28%
11 kV-25 kVA (3P)	6,162	11	6,173	1,790	1.83%	2.36%	6.16%	4.92%	5.96%	5.96%	3.64%	2.21%	5.28%	5.20%	1.08%	2.83%	2.29%	4.26%	2.43%	3.93%	2.05%	5.28%	2.94%
11 kV-63 kVA(3P)	6,679	11	6,690	2,033	1.30%	1.68%	4.38%	3.50%	4.24%	4.24%	2.59%	1.57%	3.57%	3.70%	0.77%	2.02%	2.66%	3.03%	1.73%	2.80%	1.46%	3.57%	2.09%
11 kV-10 kVA (1P)	4,580	11	4,591	1,221	2.63%	3.39%	8.83%	7.06%	8.54%	8.54%	5.22%	3.16%	7.56%	7.45%	1.55%	4.06%	3.30%	6.11%	3.48%	5.63%	2.94%	7.56%	4.21%
11 kV-16 kVA (1P)	4,644	11	4,655	1,365	2.42%	3.12%	8.14%	6.50%	7.87%	7.87%	4.81%	2.92%	6.97%	6.87%	1.43%	3.74%	4.71%	5.63%	3.21%	5.19%	2.71%	6.97%	3.88%
11 kV-25 kVA (1P)	4,656	11	4,667	1,432	1.63%	2.11%	5.49%	4.39%	5.32%	5.32%	3.25%	1.97%	4.71%	4.64%	0.96%	2.53%	4.71%	3.80%	2.17%	3.50%	1.83%	4.71%	2.62%
Covered Conductor Line Transformers																							
33 kV-25 kVA (3P AAAC)	6,546	11	6,557	1,884	1.42%	1.84%	4.79%	3.83%	4.64%	4.64%	2.83%	1.72%	4.10%	4.04%	0.84%	2.20%	1.67%	3.31%	1.89%	3.06%	1.60%	4.10%	2.28%
33 kV-63 kVA (3P AAAC)	7,105	11	7,115	2,140	1.10%	1.41%	3.68%	2.94%	3.56%	3.56%	2.18%	1.32%	3.15%	3.11%	0.65%	1.69%	2.29%	2.55%	1.45%	2.35%	1.23%	3.15%	1.76%
33 kV-10 kVA (1P AAAC)	4,839	11	4,850	1,285	2.13%	2.74%	7.15%	5.71%	6.92%	6.92%	4.23%	2.56%	6.12%	6.03%	1.25%	3.29%	2.66%	4.95%	2.82%	4.56%	2.38%	6.12%	3.41%
33 kV-16 kVA (1P AAAC)	5,061	11	5,072	1,437	1.93%	2.49%	6.48%	5.18%	6.28%	6.28%	3.84%	2.32%	5.56%	5.47%	1.14%	2.98%	3.30%	4.49%	2.56%	4.14%	2.16%	5.56%	3.09%
33 kV-25 kVA (1P AAAC)	5,044	11	5,055	1,507	1.64%	2.11%	5.50%	4.40%	5.33%	5.33%	3.25%	1.97%	4.71%	4.65%	0.97%	2.53%	4.71%	3.31%	2.17%	3.51%	1.83%	4.71%	2.62%
11 kV-16 kVA (3P AAAC)	5,924	11	5,935	1,285	2.05%	2.64%	6.89%	5.51%	6.67%	6.67%	4.07%	2.47%	5.90%	5.81%	1.21%	3.17%	1.67%	4.76%	2.72%	4.39%	2.30%	5.90%	3.28%
11 kV-25 kVA (3P AAAC)	6,170	11	6,181	1,790	1.83%	2.36%	6.16%	4.92%	5.96%	5.96%	3.64%	2.21%	5.28%	5.20%	1.08%	2.83%	2.29%	4.26%	2.43%	3.93%	2.05%	5.28%	2.94%
11 kV-63 kVA (3P AAAC)	6,687	11	6,698	2,033	1.30%	1.68%	4.38%	3.50%	4.24%	4.24%	2.29%	1.57%	3.57%	3.70%	0.77%	2.02%	2.66%	3.03%	1.73%	2.80%	1.46%	3.57%	2.09%
11 kV-10 kVA (1P AAAC)	4,585	11	4,596	1,221	2.63%	3.39%	8.83%	7.06%	8.54%	8.54%	5.22%	3.16%	7.56%	7.45%	1.55%	4.06%	3.30%	6.11%	3.48%	5.63%	2.94%	7.56%	4.21%
11 kV-16 kVA (1P AAAC)	4,492	11	4,503	1,365	2.42%	3.12%	8.14%	6.50%	7.87%	7.87%	0.00%	2.92%	6.97%	6.87%	1.43%	3.74%	4.71%	5.63%	3.21%	5.19%	2.71%	6.97%	3.88%
11 kV-25 kVA (1P AAAC)	4,504	11	4,515	1,432	1.63%	2.11%	5.49%	4.39%	5.32%	5.32%	3.25%	1.97%	4.71%	4.64%	0.96%	2.53%	4.71%	3.80%	2.17%	3.50%	1.83%	4.71%	2.62%
Service Connections																							
Service Connection	111		115	39	1.35%	1.74%	5.04%	3.62%	4.38%	4.38%	2.68%	1.62%	3.88%	3.82%	0.79%	2.08%	2.72%	3.13%	1.78%	2.89%	1.51%	3.88%	1.16%
Service Connection	287		288	39	1.35%	1.74%	5.04%	3.62%	4.38%	4.38%	2.68%	1.62%	3.88%	3.82%	0.79%	2.08%	2.72%	3.13%	1.78%	2.89%	1.51%	3.88%	1.16%

Source: BPC RED, JPST Tabulation

5.3 Lightning Damage Prevention Program Cost

The costs for shield wire and counterpoise installation is estimated at USD 491,476 as shown in Table-5.3.1. The cost for ARCB installation is estimated at USD 1,186,692 as shown in Table -5.3.2.

Table-5.3.1 Cost Estimate for Shield Wire and Counterpoise Installation

Unit: USD

	Quantity	Unit	Unit Price	Cost
Shield Wire Installation	290	km	933	270,570
Counter-poise	700	nos	84	58,800
Civil			30%	143,035
Transportation Cost			4%	19,071
	Total			491,476

Source: JPST

Table-5.3.2 Cost Estimate for ARCB Installation

Unit: USD

	Quantity	Unit	Unit Price	Cost
33kV ARCB	20	nos	35,200	704,000
11kV ARCB	13	nos	24,100	313,300
Civil 33kV ARCB	20	nos	3,900	78,000
Civil 11kV ARCB	13	nos	3,900	50,700
Transportation Cost			4%	40,692
	Total			1,186,692

Source: JPST

5.4 Grid Extension Cost Analysis

JPST has analyzed substation unit costs as shown in Figure-5.4.1. The average investment cost per customer for each substation varies from USD 1,129 per customer for S009 in Wandue to USD 16,562 for Q003 in Trongsa. The median value of the unit investment cost is USD 5,263 per customer while the average investment cost per customer is USD 5,289.

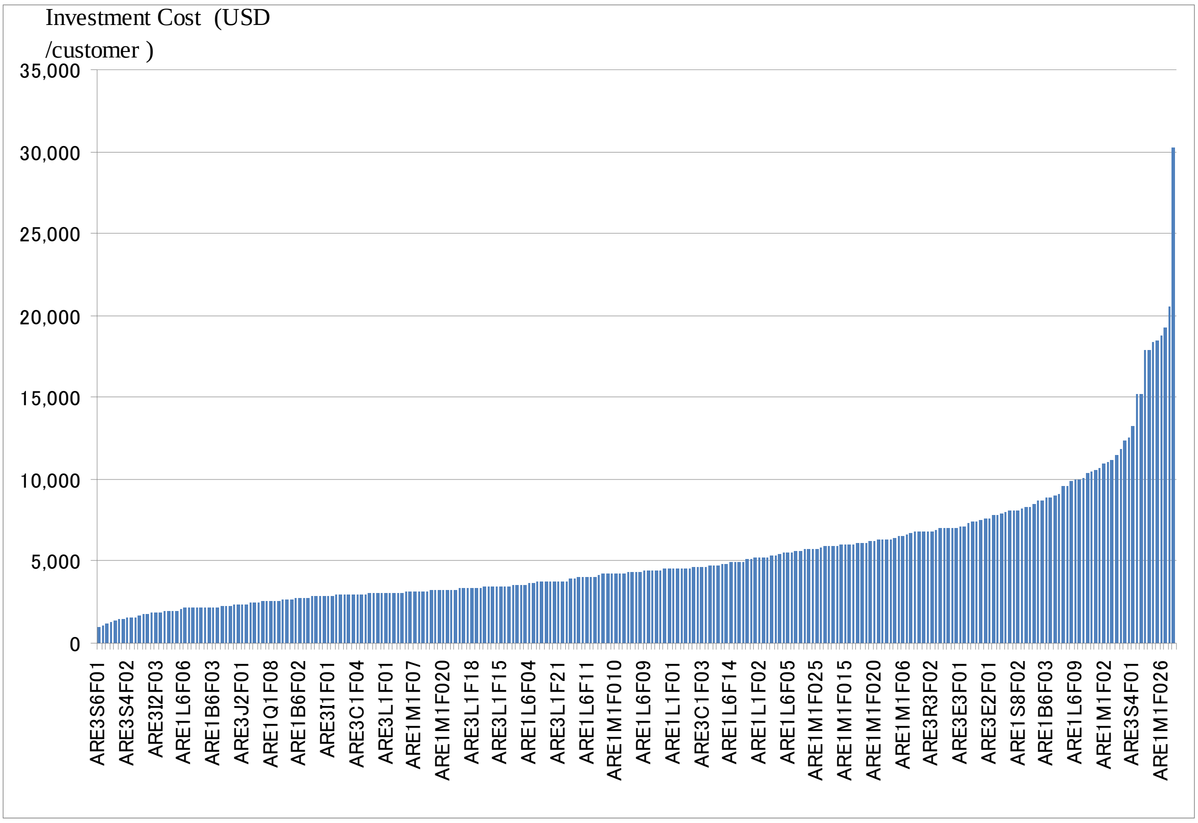
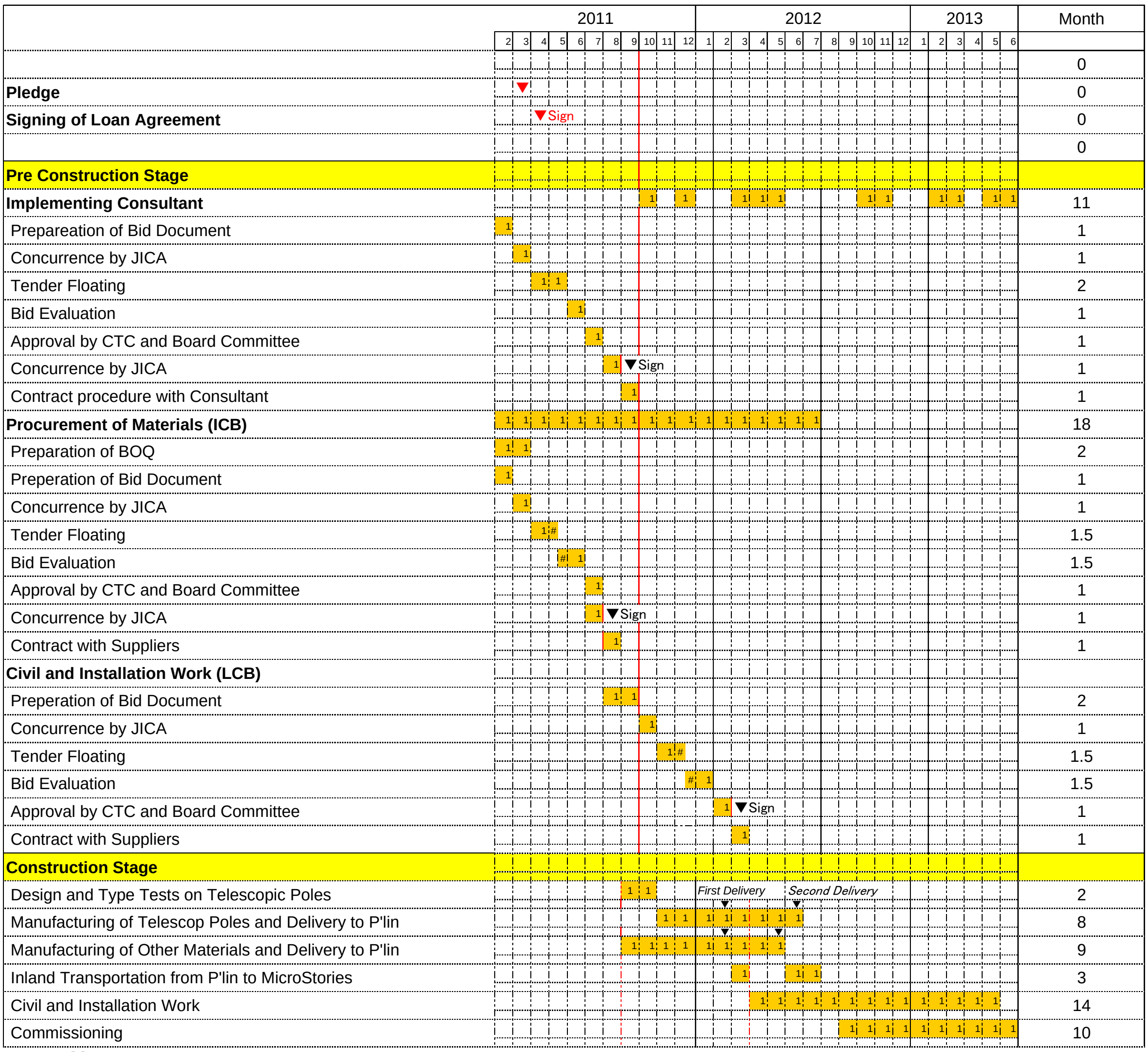


Figure-5.4.1 Unit Customer Investment Cost by Substation

CHAPTER 6 PROJECT IMPLEMENTATION PROGRAM

6.1 Implementation Schedule and Project Sub-Packages

The target completion of the Project is end of June 2013. Accordingly, the entire implementation period would only be 29 months since the Project is supposed to commence in February 2011. In order to achieve this target completion, an implementation schedule is recommended based on the past experience and the consensus between BPC and JPST as shown in Figure-6.1.1.



Prepared by JPST

Figure-6.1.1 Implementation Schedule

6.1.1 Loan Agreement

The signing of the Exchange of Notes (E/N) for the loan agreement is scheduled to be in March 2011.

BPC may commence the preparation works, such as preparation of bidding documents for selection of implementing consultant and procurement of materials, in February 2011 after prior notification (pledge), while waiting for the signing of the loan agreement.

6.1.2 Pre-Construction Stage

(1) Implementing Consultant

The procedure for the selection of implementing consultants will commence immediately when the project starts in February 2011. The consultancy services are scheduled to start after JICA concurs with the contract in the beginning of September 2011, and intermittently implemented until June 2013.

(2) Procurement of Materials

The distribution line materials like transformers, conductors, insulators, poles, etc., will be procured under one-phase bidding. The bidding procedures are undertaken through ICB in accordance with JICA Procurement Guideline.

The period for the whole bidding process (from the preparation of bidding documents to signing of contracts) is expected to be approximately seven months, including the bid floating period of 45 days.

(3) Erection Work

Selection of local contractors for the erection works will be carried out under one-phase bidding, through LCB. It will consist of approximately 50 packages, based on the number of MV feeders planned to be developed under the Project. A recommendation of erection packages proposed by JPST is shown in Appendix-Q.

6.1.3 Construction Stage

The design and manufacturing of materials will start immediately after the signing of the contract for procurement of materials. The delivery of materials to BPC's warehouse in P'ling is scheduled during the period from February 2012 to December 2012, depending on the materials.

The work is managed by packages on feeder-wise basis. The period for the entire construction work is scheduled to be within 15 months, depending on the volume of works for each package, which is generally longer than the previous project. This also takes into account the difficulty in transporting materials to the project sites in remote mountainous regions.

6.1.4 Summary of Project Sub-packages

(1) Procurement of Materials

The bidding procedures for the procurement of materials will be undertaken through international competitive bidding (ICB). The following 14 sub-packages for these procurements are recommended as summarized in Table 6.1.1.

Table-6.1.1 Bid Packages for Procurement of Materials

Lot No.	Description of package	Cost Estimate (USD)
1-A	MV STEEL TELESCOPIC POLEs, FITTINGS & ACCESSORIES FOE THE WESTERN DZONGKHAGS (CHUKHA, HAA, PARO, PHUNAKA, SAMTSE)	3,087,325
1-B	MV STEEL TELESCOPIC POLEs, FITTINGS & ACCESSORIES FOE THE EASTERN DZONGKHAGS (DAGANA, PEMAGATSHEL, SARPANG, TRONGSA, TSIRANG, WANGDUEPHODRANG)	1,943,038
2A	MV OVERHEAD BARED CONDUCTORS	1,057,728
2B	MV OVERHEAD ACCESSORIES	230,917
3	INSULATORS & FITTINGS	548,843
4A	MV COVERED CONDUCTOR, LV ABC CONDUCTORS & SERVICE CABLES	1,576,623
4B	LV TELESCOPIC POLES, ABC ACCESSORIES & DISTRIBUTION BOARDS	2,659,066
5	EARTHING EQUIPMENT	144,289
6	DISTRIBUTION TRANSFORMERS	934,609
7	SWITCHING EQUIPMENT, AUTO RECLOSER, AND ACCESSORIES	1,244,419
8	CUSTOMER EQUIPMENT - ENERGY METERS	66,314
9	MISCELLANEOUS CONSTRUCTION ITEMS	247,267
10	LIGHTNING DAMAGE PREVENTION	329,370
11	TOOLS AND VEHICLES	265,957

Prepared : JPST

The above packaging is considered to be based on BPC’s procurement experience in previous projects.

It is also recommended that the procurement of 11 m telescopic poles be separated into two packages since the total quantity will be more than 9,500 and the manufacturing period is limited to 11 months.

(2) Erection Works

The selection of contractors for erection works will be managed under the procedures for local competitive bidding (LCB). The bid packages will be split by BPC based on medium voltage (MV) main feeders during the preparation of bidding documents in the pre-construction stage.

Considering the contract volume and the geographical proximity of erection site, a recommendation of feeder-basis sub-packages of erection works is shown in **Appendix-Q.**

6.2 Implementation Method

The implementation for RE by BPC is vertically divided into three components, namely: procurement, transport, and erection works, instead of commissioning the entire work to a single or multiple contractors as a package. The method has been proved to work effectively especially in terms of controlling the material procurement costs, meeting timely delivery of the materials, and directly awarding the erection works to local contractors. In order to execute the work properly, BPC has set up a fairly large project implementation organization, involving the RED as well as the PSD. There is no merit in altering the work process that has worked relatively well in the past at this juncture.

6.3 Implementation Setup

6.3.1 Organization

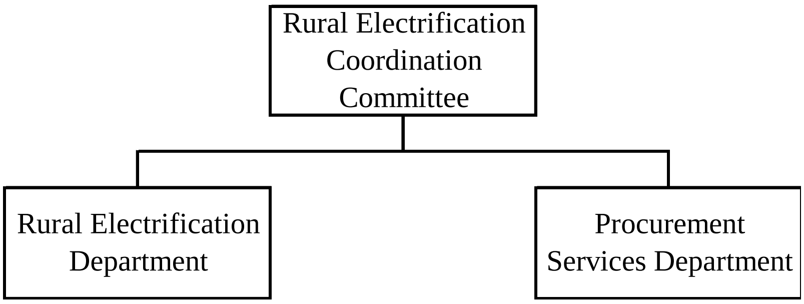
The project will constitute the last portion of RE in Bhutan. Prior to the last stage, the RGoB already received four loans from ADB and one loan from JBIC (now merged with JICA) to execute RE projects. During the implementation of the RE packages, BPC has established the RED as a permanent organization for the planning and execution of RE projects. Chapter 5 describes its function and setup in detail. Table-6.3.1 shows the summary of RE work and the responsible departments.

Table-6.3.1 Rural Electrification Work and Responsible Organizations

Process	Organization in Charge
Material Procurement	Procurement Department
Inventory Control and Transport	Procurement Department
Construction Supervision	Rural Electrification Department
Operation and Maintenance	Electricity Service Division

Source: BPC

As indicated in Section 6.3.3, there is a concern on meeting the deadline of completion in 2013. One of the critical measures is to minimize the procurement lot and synchronize the procurement-transport-erection work flow. Therefore, it is necessary to establish a closer coordination between PSD and RED. It is recommended to create an ad hoc coordination body above the two departments to realize the much needed coordination.



Source: JPST

Figure-6.3.1　Recommended RE Organization

6.3.2 Manpower

RED has some 160 staff in its headquarters and regional offices. Prior to the implementation of the first Japanese ODA loan, the SAPROF study recommended the expansion of RED staff from 44 to 170 to cope with increased workload for the JBIC package as well as ADB RE-4. BPC has pursued the recommended staff increases earnestly. Although the work volume of the next phase of electrification may be somewhat less, it may be even larger than what is required at present due to the very tight implementation schedule. However, taking into account the demobilization of RED after the Project, it would be more advantageous not to alter the current size of the department.

6.3.3 Strategy to Meet 2013 Deadline: Just-In-Time to be Revisited

For the on-going Japanese ODA loan project, the SAPROF study recommended the introduction of just-in-time system to the procurement and inventory control in order to reduce delivery period as well as time wasted arising from inflated inventories. However, the recommendation was not taken up, hence, the conventional large lot based procurement was undertaken. As a result, there was no improvement in delivery period and large stagnant inventories. Sending the large order means that the manufacturers need to store the outputs and only after having met the required quantity that they ship the materials. In other words, the products produced in the beginning have to wait until the last product is produced before shipment. Reduced lot means reduced waiting period. If the first products were shipped immediately, construction using said products would have been shortened by the entire production period. Minimization of the lot size and synchronization of installation process should be an integral part to meeting the national deadline.

Naturally, each product cannot be shipped on a single basis, thus, a minimum lot size that does not inflate transport and handling costs need to be sought out. Discussion with PSD has revealed that there are both visible administrative and hidden costs in cross-border shipment such as waiting time. This transaction costs need to be factored into the determination of lot sizes. One suggestion that has emerged from the discussion is to adopt one month cycle of production and shipment. For most of the products, one month production would generate more than one truckload. This transportation cost would not be increased by lot size reduction. In addition, monthly delivery will have a standardization effect on administration including documentation, and also logistics. The manufacturer would need less space for inventory and the freight transporter needs fewer vehicles or less capacity for each trip, but which should be more frequent. Therefore, it could lead to reduction of costs as well. Lot size optimization needs to be studied for each procurement package before tendering, in consultation with the vendors in order to create a win-win situation.

6.3.4 Contractor Education and Information Sharing: Reforming Tender Documents and Consultation

The last package of rural electrification is supposed to have a larger proportion of civil costs within the total project budget due to more remote locations of the project feeders. The largest contributor in the cost escalation is the human transport of materials to construction sites, so called head-loading work. At present, the tender documents require the bidder to provide costs per unit length of conductor line or unit costs per transformer which include local transport (from the regional store to the road end nearest to the construction site), head-loading, and erection. JPST conducted unit cost analyses for civil works; however, the tender results did not provide any information with regard to costs associated with each type of work such as transport or erection. Moreover, the results of analysis show some inconsistencies such as no statistically meaningful deviation in costs between single phase and three-phase conductor line work, despite the fact that the total weight of conductors is 50% more for three-phase compared to single phase. Or, a larger transformer had fetched lesser prices. These statistical anomaly leads to a hypothesis that the contractor is bidding without detailed examination of transport loads and required manpower. There are numerous reports of contractors’ complaints on excessive difficulties arising from head-loading work. JPST’s conjecture is that these complaints are emanating from those uninformed and underprepared contractors without knowing how many people and how long it takes to carry heavy and long equipment on mountainous terrain.

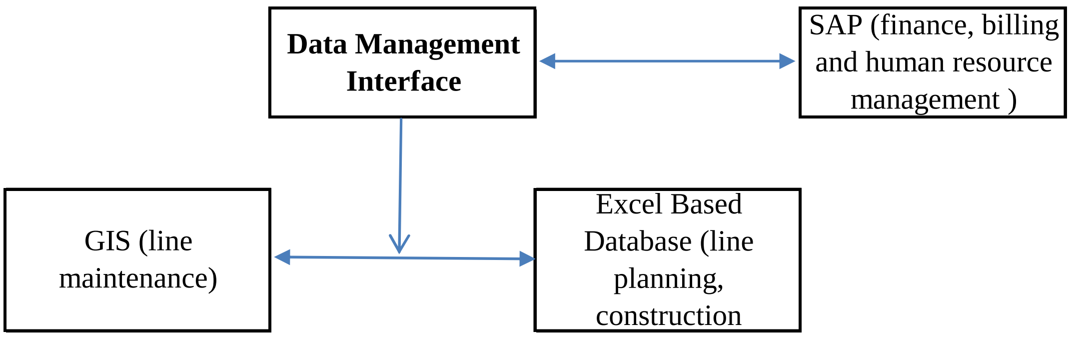
Given the priority, which is to meet the deadline in 2013, and to ensure proper installation of equipment and facilities, it is reasonable to employ well-informed contractors with well-prepared logistical plans for transport and erection. The contractor should be informed about the length, volume and weight of the materials to be transported and installed for better planning on their part. Detailed information sharing will do some justice by avoiding unnecessary losses on the part of the contractor or delays in construction. Therefore, it is recommended that the bid documents should contain all the relevant planning data for the contractors including the weights of the materials to be used in construction as well as the transportation distance. Some workshops related to past experience and best practices may be given by BPC to contractors to enhance their planning capacity.

6.3.5 Data Management

There are currently three data management systems working within BPC. One is much centrally controlled and so-called data management for financial transactions and customer database management; the second is the GIS database introduced since the beginning of JICA RE-1 project; and the third consists of numerous reports compiled in excel formats such as progress monitoring sheets and fault records. BPC has decided to introduce SAP as the main application to handle most of the critical and centrally controlled database. GIS is now fully utilized in the planning of both MV and LV lines in conjunction with GPS.

Given the ease of use, familiarity and wide availability of excel within the BPC, it would be most efficient and cost-effective to use excel as the basic platform for data entry interface. There will be less need for human resource development and less costs associated with the introduction of the software. It is envisaged that the next generation web computation will have similar format and style of commands, and thus, investment for human resource training will not lose continuity. The problems also come with ease and flexibility. The inconsistency in data entry formats and tabulation leaves the file formats to the whim of the data operators and in return, the aggregation process becomes extremely difficult and time consuming to rectify the individual variations as well as errors. The existence of decentralized files makes statistical or planning analysis very difficult. Often, the data are transferred from one file to another manually, requiring large wasteful manpower in data processing. The data file such as those containing fault records with tens of thousands of records are left without being utilized for strategic analyses. In most cases, the data in excel formats are used for the purpose of printing hard copies in standard formats and not for analyses or planning. Another problem for the decentralized data compilation is security. The maintenance of chronic file records and keeping the most updated data for common access is not easy while protecting the data from accidental or intentional losses.

BPC has developed an array of reporting data files which could potentially be a wealth of data for strategic planning. In order to achieve that purpose, there needs to be a mechanism or protocol to be developed for the transfer, aggregation and analyses. It is therefore recommended that as part of capacity building, data entry, management, security and analyses protocol, and software should be developed together with the human resources to manage the overall database system from management and strategic points of view. The database integration process with a purpose of integrated strategic monitoring and planning is a requisite for the subsequent capacity building.



(Prepared by JPST)

Figure-6.3.2 Database Integration Concept

6.3.6 Reinforcement of Operation and Maintenance Capacity

Given the geographical expanse of the next rural electrification and the difficulty in accessibility, there should be more reinforcement of operation and maintenance capacities. On the other hand the operation and maintenance for rural electrification in the next phase is purely a financial burden on the part of BPC. Thus there is a strong need for keeping the cost as low as possible at the same time. As discussed in the section on manpower above, the personnel size of ESD, RECD and RECSD should be maintained at the same level as of now. Strengthening should be focused on the management efficiency. One areas that is critical is to provide the field staff with adequate tools and means of communication.

As mentioned in 10.3.4, NLDC will be inaugurated in next year the data transmission and communication situation among generating and substation facilities and relevant offices which are covered by NLDC will be tremendously improved. Hence, it is required effective data transmission from ESD, RECD and RECSD to RED for the effective management and construction supervision/monitoring. The following issues are recommended for the reinforcement of O & M capacity..

- ✓ Vehicles: many field officers lack in means to travel efficiently. Appropriate motorcycles and automotive vehicles should be provided.
- ✓ Equipment and tools : necessary equipment and tools especially required for the emergency recovery work from power interruption should be provided to improve the system reliability.
- ✓ Measuring instrument and tools : measuring instrument such as earth resistance tester, digital multi-meter and tools such as torque wrench, etc. which are required for the commissioning test and regular maintenance work should be provide to execute these works on time.
- ✓ Items for safety : safety items such as safety helmet and safety belts, etc. should be provided for all field officers.
- ✓ Telecommunication: more mobile phone should be deployed to field officers as the coverage of the mobile network is covering the major part of the country soon.

And, BPC needs to give serious planning efforts to the coordination of the alignment of the MV routes to the future road alignments. This should provide large cost reduction in maintenance and operation costs.

Village Technician Program, initiated by ADB, should be reinforced as well to supplement the work to be done in remote areas.

6.4 Consulting Services

6.4.1 Necessity of Consulting Services

(1) Time Constraints and Facility Management

The RGoB had decided to supply electricity to all people in Bhutan by June 2013. For this purpose, ADB RE-5 and JICA RE-2 are planned to be implemented. The implementation schedule is plotted using critical path method which accordingly shows that no idle time is allowed to realize the completion date of the project as mentioned before. Time constraints is one of the main reason why foreign consultant is required to BPC, and as mentioned in (5) of this sub-clause, technical transfer on data arrangement for facility management is the most important issue to BPC.

(2) Coordination of Contract Packages

Procurement of the materials will be conducted through a number of contracts. Basically, one contract allotted is for one kind of material. The construction of distribution lines will also be carried out by a number of local contractors. During the peak period of the project, the total number of contracts will be around 50. Timely and well organized coordination among contract packages is significantly important to achieve efficient project implementation

(3) Material Delivery to the Project Site

Materials such as telescopic poles, insulators and conductors shall be delivered at the project site according to delivery schedule to complete the project on time. The timely material delivery to the site is also one of the most important issues for the idle-time free implementation of the project.

(4) Assistance for Bidding

Preparation of bid documents, bidding and bid evaluation process are subject to time constraints despite being the most significant works in the project implementation.

(5) Arrangement of feeder-wise Diagram

The line information such as support, kind of conductor, line length, etc., is arranged and controlled in the GIS. Also, the same information is used in the MI Power (Application Program for Load Flow Study).

The feeder-wise diagram, which may include number and capacity of transformers, kind of conductors, line length, etc., may be produced by extracting the necessary data from the database of MI Power.

Actually, handwritten diagrams have been prepared at some RECD or RECSD. Thus, only the person who prepared the diagram knows the distribution system.

JPST faced difficulty in reviewing the load flow study, and it was time-consuming work to know the feeder-wise information from the “Load Flow Study Diagram”.

(6) Ledger of Distribution Facilities

Together with the feeder-wise diagram, all feeder information should be arranged on the ledger so that all information on the distribution line can be commonly utilized by the personnel concerned.

6.4.2 Scope of Work

The scope of work of international consultant includes monitoring and construction schedule control, technical assistance and technical transfer for:

(1) Procurement of Materials

a. To review and endorse drawings and documents submitted by Suppliers for approval;

b. To carry out factory inspections on manufacturing equipment and materials, when necessary;

c. To assist BPC in monitoring the manufacturing and delivery by the Suppliers on schedule.

(2) Erection Work

a. Construction Supervision

- Review and endorse all proposed plans, schedules and documents regarding Project implementation and construction work submitted by the Contractor for approval;
- Check to ensure the Contractor's adherence to approved plans and schedules;
- Check and inspect work quality and quantity;
- Conduct additional field visits in order to assist BPC monitor the field works whenever necessary;
- Advise on the methods of measurement and computation of work volume and provide assistance on the verification of the contract progress and payment;
- Prepare reports of inspection, tests and supervision activities;
- Supervise and approve as-built drawings prepared and submitted by the Contractors;
- Conduct final inspection and witnessing tests to issue the Certificate of Completion to the contractor;

b. Design Modification

The Consultant shall make revisions and adjustments of design from time to time when they become necessary due to findings in the field or to incorporate relevant comments from concerned agencies.

c. Coordination with other rural electrification programs

The Consultant wil1 assist BPC in coordination with other rural electrification programs on-going simultaneously with the Project.

d. Preparation of feeder-wise single line diagram and ledger of distribution facilities
The Consultant wil1 assist BPC in preparation of feeder-wise single line diagram and ledger of distribution facilities.

6.4.3 Requirement for Consultant

One of the major contribution to expected on the consultant is to streamline and optimize the procurement processes to meet the deadline of 2013. Therefore the consultant needs to fulfill the following qualification;

- ✓ At least five (5) projects of experience in consultancy services for supervision of implementation of power electricity projects in overseas countries (experience in Bhutan desirable), and
- ✓ At least one (1) project of experience as team leader or project manager for consultancy services under the project financed by JICA or JBIC.

6.4.4 Consulting Cost Estimate

Given the extension of the present consulting work to cover the tender documentation and its evaluation work, the main work for the consulting services is construction supervision. The workload for consulting work is one person team for consulting on construction supervision with 11 person-months in total. The estimated cost for consulting is 45 million yen inclusive of overhead and per diem.

6.4.5 Personnel Assignment and Schedule

The required personnel include a project manager. His assignment is shown in the Implementation Schedule in Figure-6.1.1.

CHAPTER 7 ECONOMIC AND FINANCIAL EVALUATION

7.1 Methodology

Economic evaluation is conducted by deriving the economic internal rate of return on investment (EIRR), which is a particular discount rate to equate the net present values (NPV) of economic benefit and cost streams. The economic benefits are defined as the consumer benefit arising from access to grid power for households without electricity. The consumer benefits are defined as the summation of marginal willingness-to-pay for the services provided by grid electricity

7.2 Economic and Financial Analysis Method of Distribution Line Project

(1) Economic Benefit from Grid Access

According to the technical specifications delineated in **Appendix D.2 Economic Benefit Estimation Methodology**, the JPST has estimated consumer benefits arising from five different activities, namely: 1) lighting, 2) radio listening, 3) TV viewing, 4) heating and power, and 5) mobile phone use, as well as cost savings permitted by grid electrification. Table-7.2.1 shows the summary of the estimated consumer benefits from grid electrification per household basis. The total benefit is estimated to be 1,168 Nu per household per month. The consumer benefit for each activity component is detailed in **Appendix D.1 Economic Benefit Estimation.**

Table-7.2.1 Summary of Grid Electrification Benefits

Summary of Benefit	Unit	Consumption		Price (Nu. Per unit)		Benefit (Nu./Month)
		Non-electrified	Electrified	Non-electrified	Electrified	
Lighting	k-lumens	3.7	480.0	18.3	0.1	335
Radio-listening	hours	18	72	7.5	0.036	46
TV-viewing	hours	7.2	103.5	9.5	0.2	102
Heat and power	kWh-equivalent	125	78	6.8	4.2	128
Mobile phone	minutes	57.6	114	2.6	2.0	159
Cost Saving from Electrification				879	481	398
Total						1,168

(Prepared by JPST)

There are other intangible benefits to electrification. One particular importance is the increase in productivity of cottage industries. Also, it has brought educational impacts to children. A range of cottage industries are not thoroughly surveyed in Bhutan but kira and gho (national dress) production is an essential source of income for rural households. Studies on educational impacts have not yet substantiated. However, access to TV and radio will enhance the availability of information as well as provide entertainment for rural population at large. Another benefit is the promotion of public health. The use of firewood and its indoor air pollution contributes to respiratory diseases in non-electrified areas. A reduction in firewood is expected to reduce the prevalence of respiratory diseases in the rural areas

(2) Economic Benefit from Reliability Improvement

Based on the fault records compiled by BPC during 2007-2009, the following summary of lightning damages is obtained.

Table-7.2.2 Summary of Lightning Damages

	Customer (nos)	Loss Duration (hours)	Lost Energy Consumption (kWh)	Economic Loss (USD thousand)
2007	267	309.93	62,587	29
2008	195	210.1	44,193	20
2009	202	178.5	55,617	26
Average	221	233	54,132	25

Note: unit economic value for lost kWh is assumed at USD 0.46/kWh
The average kW load per customer is assumed at 0.4kW.

(Prepared by JPST)

It is presumed that the planned Reliability Improvement Program will have an effect to reduce the number of incidences in half, which, on the average, reduces the economic loss to approximately USD 12,500. The reduction will lead to the decrease in operation and maintenance costs but there is no unit cost calculation per such incidence. Thus, cost savings on maintenance is excluded from the economic benefit estimation.

7.3 Economic Evaluation Results for the Distribution Line Project

Economic cash flow analysis has been conducted for the Project period of 30 years with an investment program to be accomplished during 2011-2013. Procurement of materials for the Project will only be finished in 2011. The total number of customers to be added will be 3,701. It is assumed that one third of service connections are completed in 2012 and the remaining balance in 2013.

Table-7.3.1 Economic Evaluation Parameters

	Unit	Parameters
Total Consumers Under Plan	Nos	3,701
Investment Planned	USD million	28
Material Cost	USD million	14
Civil Cost	USD million	7
Transport Cost	USD million	0.2
Household Demand	kWh/month	112
Other	%	30
Total Demand Per HH	kWh	145.6
Willingness-To-Pay	USD/kWh	0.23
Reliability Improvement Benefit	USD million	0.125
Transmission Loss	%	20%
Power Generation Cost	USD	0.027
Net Value of WTP	USD	0.20
Annual Growth to 2015	% per annum	5%
Annual Growth 2010-20	% per annum	5%
Annual Growth 2020-40	% per annum	3%
Grid Annual OM Cost	USD per Customer	64
Project Life for Grid	years	30

(Prepared by JPST)

Based on the cash flow streams tabulated in Table-7.3.2, the EIRR has been calculated. The estimated EIRR is 7.3%, with an NPV discounted at 12% of USD -9.3million.

Table-7.3.2 Results of Economic Evaluation

Unit: USD Million

NPV @12% (USD million)	-9.3
EIRR	7.3%

(Prepared by JPST)

Table-7.3.3 Project Economic Cash Flow Table

Unit: Million USD

Year	Number of Customer	Economic Benefit from Grid Access	Economic Benefit from Reliability Improvement	Investment	Power Generation Cost and Transmission Loss	Operation and Maintenance	Net Cash Flow
2010							
2011				11.5			-11.5
2012	1234	0.55		11.7	0.07	0.08	-11.3
2013	2468	1.15	0.06	4.4	0.1	0.16	-3.5
2014	3,701	1.81	0.13		0.21	0.24	1.5
2015	3,701	1.90	0.13		0.21	0.24	1.6
2016	3,701	1.99	0.13		0.21	0.24	1.7
2017	3,701	2.09	0.13		0.21	0.24	1.8
2018	3,701	2.20	0.13		0.21	0.24	1.9
2019	3,701	2.31	0.13		0.21	0.24	2.0
2020	3,701	2.42	0.13		0.21	0.24	2.1
2021	3,701	2.50	0.13		0.21	0.24	2.2
2022	3,701	2.57	0.13		0.21	0.24	2.3
2023	3,701	2.65	0.13		0.21	0.24	2.3
2024	3,701	2.73	0.13		0.21	0.24	2.4
2025	3,701	2.81	0.13		0.21	0.24	2.5
2026	3,701	2.89	0.13		0.21	0.24	2.6
2027	3,701	2.98	0.13		0.21	0.24	2.7
2028	3,701	3.07	0.13		0.21	0.24	2.7
2029	3,701	3.16	0.13		0.21	0.24	2.8
2030	3,701	3.26	0.13		0.21	0.24	2.9
2031	3,701	3.35	0.13		0.21	0.24	3.0
2032	3,701	3.45	0.13		0.21	0.24	3.1
2033	3,701	3.56	0.13		0.21	0.24	3.2
2034	3,701	3.66	0.13		0.21	0.24	3.3
2035	3,701	3.77	0.13		0.21	0.24	3.5
2036	3,701	3.89	0.13		0.21	0.24	3.6
2037	3,701	4.00	0.13		0.21	0.24	3.7
2038	3,701	4.12	0.13		0.21	0.24	3.8
2039	3,701	4.25	0.13		0.21	0.24	3.9
2040	3,701	4.38	0.13		0.21	0.24	4.1
2041	3,701	4.38	0.13		0.21	0.24	4.1
2042	3,701	4.38	0.13		0.21	0.24	4.1
2043	3,701	4.38	0.13		0.21	0.24	4.1

(Prepared by JPST)

7.4 Financial Evaluation

Financial evaluation was undertaken to explore financial sustainability of further rural electrification. The cash flow as shown in Table-7.3.3 was created in order to simulate financial impacts of rural electrification on BPC. The parameters for the simulation are summarized in Table-7.4.1.

Table-7.4.1 Parameters for Financial Cash Flow Simulation

	Unit	Parameters
Total Customers Under Plan	Nos	3,701
Investment Planned	USD million	31
Material Cost	USD million	14
Civil Cost	USD million	7
Transport Cost	USD million	0.2
Household Demand	kWh/month	112
Other	%	30
Total Demand Per HH	kWh	145.6
Tariff	USD	0.024
Reliability Improvement Benefit	USD million	0.075
Transmission Loss	%	20%
Power Purchase Cost	USD	0.003
Annual Growth 2010-20	% per annum	2%
Annual Growth 2020-40	% per annum	2%
Grid Annual OM Cost	USD per Customer	64
Project Life for Grid	years	30

(Prepared by JPST)

The assumed parameters are synonymous to those used for economic evaluation. Instead of WTP increases, the increases in the demand for power are assumed to continue at the rate of 2% per year until 2040. Operation and maintenance costs are estimated at USD 64 per customer basis as shown in Appendix-D for OM Cost Analysis. It is assumed that BPC is able to purchase the generated energy at the cost of Nu 0.13 per kWh from the Royal Energy at a subsidized price.

The simulated cash flows are shown in Table-7.4.3. The net cash flow marginally turns surplus after 2014. In the end, NPV calculation shows a negative value for the Project and a financial rate of return on investment with also a negative value at -11.7%. Rural electrification power demand comprises less than 4% of total power demand in Bhutan. Thus negative return on the investment in rural electrification does not affect the overall financial situation of BPC. Thus BPC regards rural electrification as part of their corporate social contribution. In addition, BEA evaluates every activity of BPC including rural electrification to make sure it does not incur direct financial losses.

Table-7.4.2 Financial Evaluation Summary

Unit: USD Million

NPV @12% (USD million)	-25.6
FIRR	-11.7%

(Prepared by JPST)

Table-7.4.3 Financial Cash Flow Analysis of Rural Electrification Work

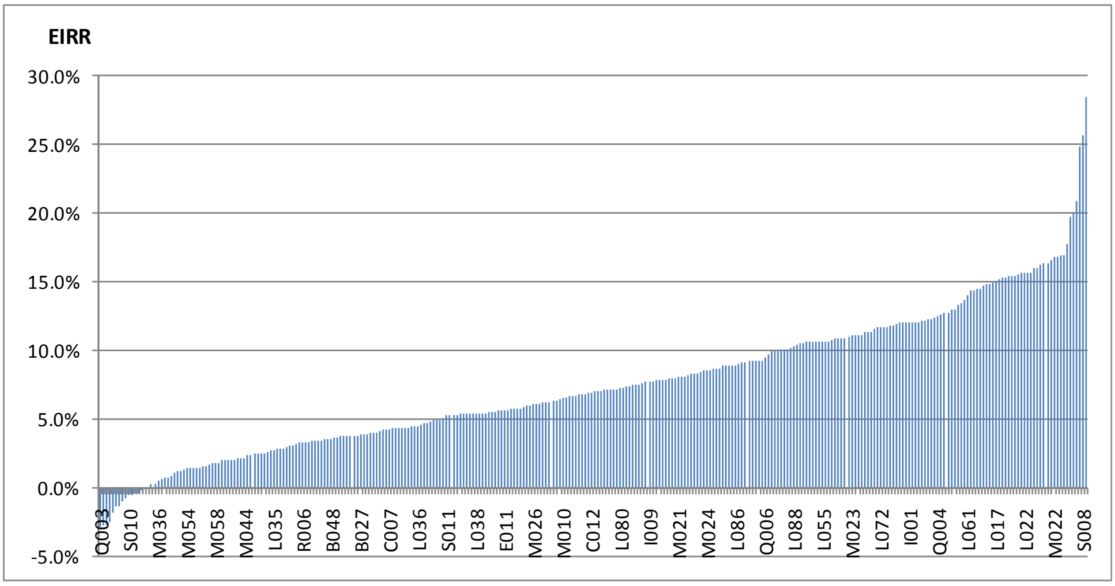
Unit: Million USD

Year	Number of Customer	Economic Benefit from Grid Access	Economic Benefit from Reliability Improvement	Investment	Power Generation Cost and Transmission Loss	Operation and Maintenance	Net Cash Flow
2010							
2011				12.7			-12.7
2012	1234	0.05		13.0	0.01	0.08	-13.0
2013	2468	0.11	0.04	5.6	0.0	0.16	-5.6
2014	3,701	0.17	0.08		0.02	0.24	0.0
2015	3,701	0.17	0.08		0.02	0.24	0.0
2016	3,701	0.18	0.08		0.02	0.24	0.0
2017	3,701	0.18	0.08		0.02	0.24	0.0
2018	3,701	0.18	0.08		0.02	0.24	0.0
2019	3,701	0.19	0.08		0.02	0.24	0.0
2020	3,701	0.19	0.08		0.02	0.24	0.0
2021	3,701	0.19	0.08		0.02	0.24	0.0
2022	3,701	0.20	0.08		0.02	0.24	0.0
2023	3,701	0.20	0.08		0.02	0.24	0.0
2024	3,701	0.21	0.08		0.02	0.24	0.0
2025	3,701	0.21	0.08		0.02	0.24	0.0
2026	3,701	0.22	0.08		0.02	0.24	0.0
2027	3,701	0.22	0.08		0.02	0.24	0.0
2028	3,701	0.22	0.08		0.02	0.24	0.0
2029	3,701	0.23	0.08		0.02	0.24	0.0
2030	3,701	0.23	0.08		0.02	0.24	0.0
2031	3,701	0.24	0.08		0.02	0.24	0.1
2032	3,701	0.24	0.08		0.02	0.24	0.1
2033	3,701	0.25	0.08		0.02	0.24	0.1
2034	3,701	0.25	0.08		0.02	0.24	0.1
2035	3,701	0.26	0.08		0.02	0.24	0.1
2036	3,701	0.26	0.08		0.02	0.24	0.1
2037	3,701	0.27	0.08		0.02	0.24	0.1
2038	3,701	0.27	0.08		0.02	0.24	0.1
2039	3,701	0.28	0.08		0.02	0.24	0.1
2040	3,701	0.28	0.08		0.02	0.24	0.1
2041	3,701	0.28	0.08		0.02	0.24	0.1
2042	3,701	0.28	0.08		0.02	0.24	0.1
2043	3,701	0.28	0.08		0.02	0.24	0.1

(Prepared by JPST)

7.5 Economic Evaluation by Substation

Economic evaluation has been conducted by substation level for grid extension. There is a wide spread in the resultant EIRR as shown in Figure-7.5.1. More specific data are listed in Appendix-P Economic Internal Rate of Return on Investment by Substation.



(Prepared by JPST)

Figure-7.5.1 Economic Internal Rate of Return on Investment by Substation

Dolongdo Village (S009) of Bjina Gewog in Wangdue dzongkhag of the Feeder ARE3S6 is expected to achieve the highest EIRR with 28% and the lowest, -2.9% by Karshong School Area (Q003) of the Feeder ARE3Q1 in Nubi Gewog of Trongsa dzongkhag. The median EIRR is 7%.

At the interim reporting, the JPST had suggested to set up a per-customer- investment-threshold of USD 8,000 per customer to screen the overly expensive sub-feeders in order to maintain the overall economic efficiency. However, BPC as well as DOE was willing to pursue more inclusive electrification to provide grid electricity to the extent possible to rural population. Social consideration is now overriding policy priority after the Bhutanese Parliament had taken up a resolution of “Electricity for All by 2013.” DOE has also expressed its policy standpoint to view solar home system as a temporary relief measure but not permanent solution.

From economic efficiency standpoint, the JPST is in the opinion of instilling the maximum investment threshold of USD 8,000. It is not in the position to reconcile national policy balance over social equity and efficiency.

7.6 Cost Comparison of the Work

Table 7.6.1 shows the comparison of the work scope with other donors. The discussion of cost comparison was made from the viewpoint of 1) MV line cost per kilometer and 2) MV line cost per customer.

(1) Cost comparison per kilometer

Austria's case (Gasa dzonkhag) shows the highest cost of USD 39,230/km, followed by the ADB RE-5 and JICA RE-2. Gasa dzonkhag has very long headloading distance of 36.8km and high altitude. The electrical facilities constructed in high altitude requires high insulation level which resulted in the high material cost. ADB RE-5 and JICA RE-2 are still left with long headloading distance.

With respect to the three cases such as JICA RE-2, ADB RE-5 and Austria's case (Gasa dzongkhag), these costs of MV line per kilometer are within the comparable range, followed by the JICA RE-1, however, ADB RE-4 shows a big difference from others as USD 24,359/km, hence it can be considered that the condition for cost estimation is one of a main reason. In the comparison of JICA RE-2 and ADB RE-5, the costs per kilometer of MV lines are almost level because the same specification is applied for both cases.

(2) Cost comparison per customer

JICA RE-2 shows the highest cost of USD 5,712 per customer, followed by the Austria's case (Gasa dzongkhag). It is easily understand that both JICA RE-2 and Gasa's cost are influenced by long headloading transportation, and specific issue for Gasa is higher insulation level of the materials, at the same time JICA RE-2 is planned in the sparsely populated remote area.

There is a big difference USD 1,738 (5,752 – 4,014) per customer between JICA RE-2 and ADB RE-5. This means ADB RE-5 has densely packed feeders in Mongar, S.J, and there is more customer per unit length of MV line, makes it more economically efficient.

Table-7.6.1 Cost Comparison with Other Donors

Project	Total cost (USD million)	MV line length (km)	Customer (Nos)	Cost per MV length (USD/km)	Cost per Customer (USD/customer)	MV line length per Customer (km/customer)	Reference
JICA RE-1	32.03	924	15,451	34,665	2,073	0.060	SAPROF Report
JICA RE-2	21.29	566	3,701	37,615	5,752	0.153	JPST
ADB RE-4	24.83	1,019	10,275	24,359	2,417	0.099	RE-4 PPTA Team
ADB RE-5	20.37	545	5,075	37,351	4,014	0.107	ADB Mission
Austria (Gasa)	1.23	31	229	39,230	5,371	0.137	JPST

(Prepared by JPST)

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CHAPTER 8 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

8.1 Environmental Acts and Regulations

Table-8.1.1 shows the environmental acts and regulations in Bhutan. The acts and regulations relating to nature conservation are well addressed. The Department of Forest (DoF) under the Ministry of Agriculture (MoA) is the overall authority for the management of forest resources and wild biodiversity. As for environmental assessment, the National Environmental Commission (NEC) provides guidelines and ensures the implementation of related acts.

Table-8.1.1 Environmental Acts and Regulations in Bhutan

	Act, rules and regulations	Responsible agency	Year of Issue
1	Forest and Nature Conservation Act (1995)	MoA	1995
2	Forest and Nature Conservation Rules of Bhutan 2000 (revised in 2006)	MoA	2006
3	“Rules on Biological Corridors” (2007) As an addendum to the Forest and Nature Conservation Rules 2006	MoA	2007
4	National Environment Protection Act	NEC	2007
5	Environmental Assessment Act	NEC	2000
6	Regulation for the Environmental Clearance of Projects and Regulation on Strategic Environmental Assessment	NEC	2002
7	Application for Environmental Clearance guideline for transmission and distribution lines	NEC	2004
8	National Environment Strategy	NEC	1998
9	Biodiversity Act of Bhutan	MoA	2003
10	Biosafety Rules and Regulations	MoA	2006
11	Biodiversity Action Plan	MoA	2009
12	National Biosafety Framework	MoA	2006
13	Seed Act of Bhutan	MoA	2000
14	Land Act of Bhutan	NLC	2007
15	Land Rules and Regulations	NLC	2007
16	Plant Quarantine Act of Bhutan	MoA	2000

Note: Prepared by JICA Preparatory Study Team

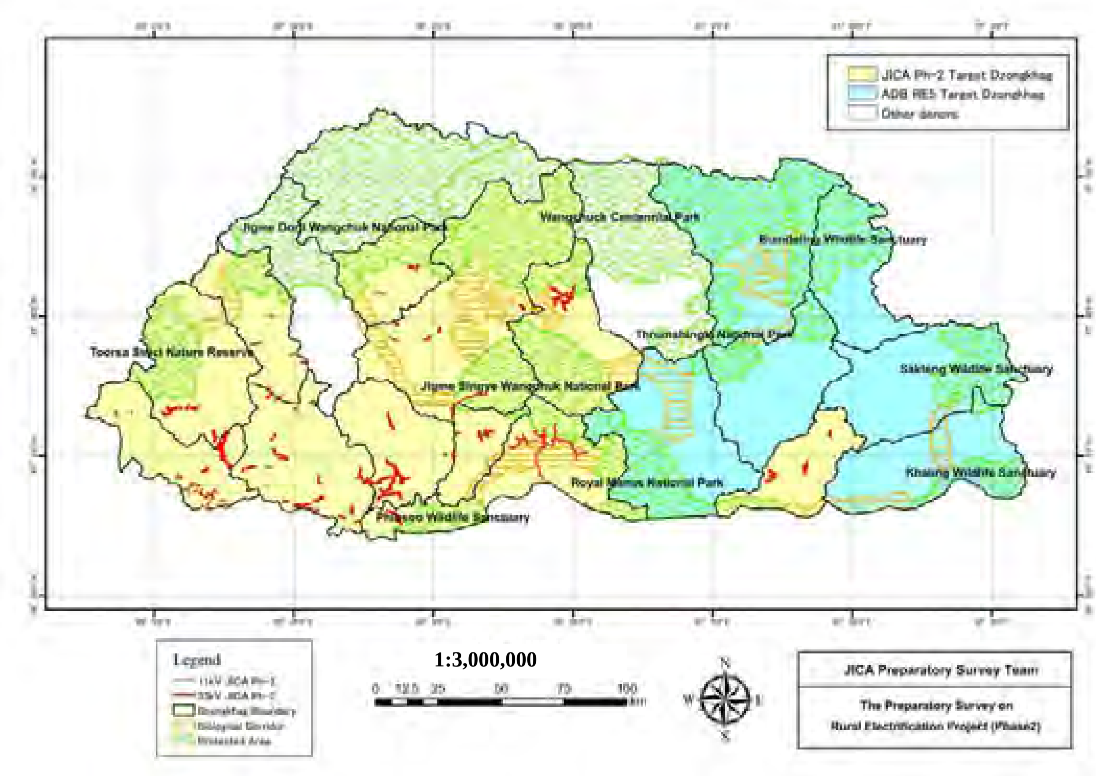
(1) Forest and Biodiversity Conservation

Bhutan has set a sizeable portion of its territory as protected areas. The Forest and Nature Conservation Act of 1995 defines "Protected Areas (PAs)" as consisting of national parks, conservation areas, wildlife sanctuaries and reserves, nature reserves, strict nature reserves, research forests and critical watersheds. The country’s protected area system consists of five national parks, four wildlife sanctuaries, and a strict nature reserve. Biological corridors (BCs) connect all ten PAs. The objective of this Act is for the protection and sustainable use of forests, wildlife and related natural resources of Bhutan. It covers forest management, prohibitions and concessions of government reserved forests, PAs, etc.

BCs are defined as “areas set aside to connect one or more PAs, which shall be conserved and managed for the safe movement of wildlife". Although BCs do not have the same status as PAs, activities such as establishing new settlements, quarrying and mining, and leasing of land for grazing are prohibited. All other development activities, including construction of roads, electricity transmission and distribution lines, and other structures, require a permit from DoF and an environmental clearance application to NEC.

It is prescribed that the territory of PAs are to be classified into the following six zones: (i) core zone, (ii) administrative zone, (iii) seasonal grazing zone, (iv) enclave zone, (v) buffer zone, and (vi) multiple-use zone. Every zone has specific roles and functions within PAs. The activities in each zone are controlled with their roles and functions. However, definite zoning has not yet been demarcated.

Figure-8.1.1 shows PAs and BCs in Bhutan and the Project Areas (JICA RE-2 and ADB RE-5).



Note: Prepared JICA Preparatory Survey Team based on Department of Forests, MoA

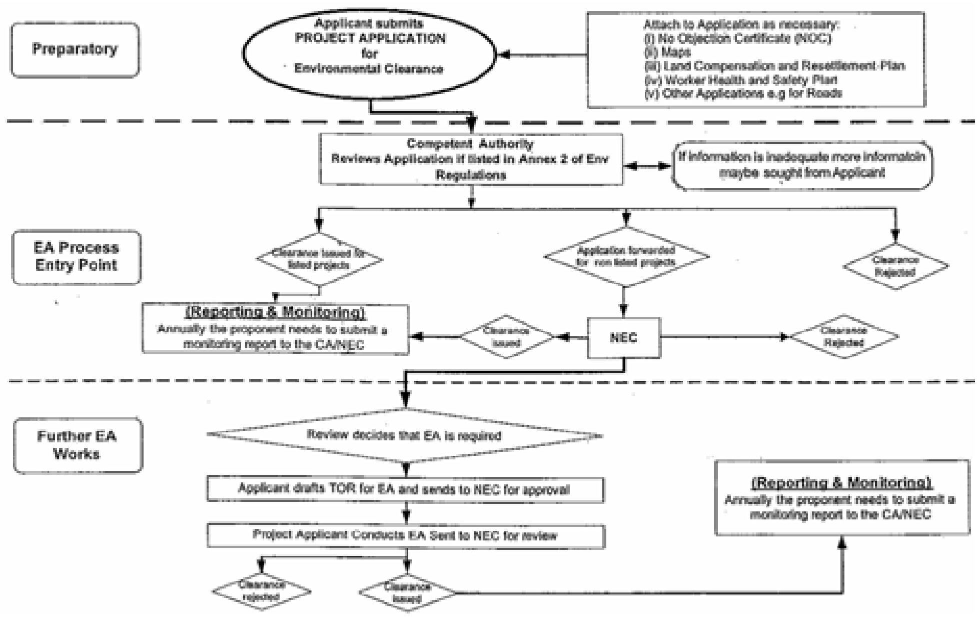
Figure-8.1.1 PAs and BCs in Bhutan and the Project Areas (JICA RE-2 and ADB RE-5)

(2) Environmental Impact Assessment

The "Environmental Assessment (EA) Act 2000", together with the "Regulation for the Environmental Clearance of Projects" and "Regulation in Strategic Environmental Assessment", comprises the legislation relating to environmental impact assessment (EIA) in Bhutan. The regulations are based on the provisions of EA Act 2000. Bhutan's Sectoral Environmental Assessment Guidelines were prepared with the assistance of the Asian Development Bank (ADB) in 1999. These guidelines were revised in 2003 to conform with the Regulation for the Environmental Clearance of Projects. The "Sectoral Guideline for Transmission Lines", originally prepared in 1999, was revised and renamed "Sectoral Guideline for Transmission and Distribution Lines" in 2003. This sectoral guideline defines necessary information and shows the format to be used in applications for environmental clearance. Thus, applications for environmental clearance of rural electrification (RE) projects must be prepared in accordance with the revised guideline.

The EA Act 2000 requires project proponents to obtain an environmental clearance (EC) from the National Environmental Commission Secretariat (NECS) prior to the implementation of projects. Figure-8.1.2 shows the environmental assessment and the approval procedure in Bhutan.

As per the requirement of the national law, a comprehensive EIA has to be carried out for all development activities as determined by NEC or the competent authority (CA). The projects taking place in the PAs of Bhutan is sensitive and usually involves EIA. The EC process starts with an initial environmental examination (IEE), a process of environmental screening for the Project. It is possible for the project to obtain EC after the IEE if the NEC or the CA is confident that the information collected during the IEE is adequate to make appropriate judgment for the issuance of EC. It is also possible that NEC or the CA might ask for more information before EC is issued. During the screening process it is also possible that depending on the severity of the impacts of the proposed project, a comprehensive EIA will have to be carried out. In this case, the terms of reference (ToR) has to be prepared by the project proponent and then submitted to NEC for approval. Only after the ToR has been approved by NEC will the process for EIA may begin. The information to be included in the application includes a specification of the proposed project, such as the number of poles, length of lines, land use, land ownership along the route, etc. as defined by the Guideline for Transmission and Distribution Lines (previously known as the Sectoral Guidelines for Transmission Lines), as shown in Table-8.1.2.



Source: Application for Environmental Clearance guideline for transmission and distribution lines, 2004 NEC

Figure-8.1.2 Environmental Assessment and Approval Procedure in Bhutan

Table-8.1.2 Environmental Legislation in Bhutan

1. Applicant's Details a) Name of project, b) name of applicant, c) contact address of applicant, d) contact person 2. Objective/s and purpose of the project 3. Name of the project financier 4. Project Details a) Site route, b)transmission line details, c) project cost, d) total number of towers/poles, e) amount of excavated material, f) implementation schedule, g) environmental unit: department responsible for environment 5. Alternative of Transmission Route 6. Project Environment a) Topography, b) land use and land tenure, c) houses and infrastructure, d) protected areas, e) access roads, f) aesthetics, g) wildlife, i cultural and heritage sites 7. Public Consultation 8. Project Impacts and Mitigation Measures 9. Monitoring Program 10. No Objection Certificate

Source: Application for Environmental Clearance guideline for transmission and distribution lines, 2004 NEC

Table-8.1.3 provides the summary of procedure for processing EC and the time limits for each process.

Table-8.1.3 Applicable Time Limits

Action time	Limit
Response by Secretariat/Competent Authority on the receipt of the application. This is simply an acknowledgement of the receipt of the application for environmental clearance.	Within 15 days
Review by the Secretariat/Competent Authorities to assess the adequacy of the application as per government rules and guidelines	1 to 3 months
Competent Authority forwards application to Secretariat for non listed projects and listed projects if it falls under Section 17 of the "Regulations for the environmental clearance of projects and Regulation on strategic environment Assessment" 2002	Within 15 days
Screening of project will be undertaken to determine the level of environmental assessment required.	1 to 3 months
If screening determines that an environmental assessment is required, the level and time frame for the assessment will be determined through negotiations between relevant parties and approved by the Secretariat/Competent Authority.	Time frame to be negotiated
Decisions/Response on the environmental clearance based on the findings of the environmental assessment report.	1 to 3 months
Public notification on decision by the Secretariat/Competent Authority	Within 15days
Appeal on the decision	Within 30 days from the date of publication of public notification
On approval of the clearance, a legal undertaking with the proponent of new projects to comply with the EA Act, 2000	10 days to 1 month
Report on the implementation of the EA Act, 2000 to the royal Government by the Secretariat/Competent Authority.	Annually

Source: Regulation for the Environmental Clearance of Projects and Regulation on Strategic Environmental Assessment, 2002 NEC

(3) Land Acquisition and Compensation

The Land Act 1979 which provides the basis for land tenure in Bhutan was revised in 2007. Under this Act, there are provisions for requisition of registered land by the government if it is required for the benefit of the country. In such cases, the affected person will be compensated with substitute land from the same dzongkhag or given cash compensation as per the prevailing land compensation rate determined by the Act.

The latest compensation rates for land acquisition were issued in 2009 and shall be revised after every three years. The Land Compensation Rates 2009 defines the rural land compensation rates, urban land compensation rates, compensation rate for building and implementation procedures. Compensation rates vary depending on land categories, dzongkhags and distances from the municipal boundary. Table-8.1.4 shows the rural land compensation rates for kamzhing (dry land).

Table-8.1.4 Rural Land Compensation Rates 2009 for Kamzhing (Dry Land)

(Amount Nu./decimal)

Sl. No.	Dzongkhag	Class A	Class B	Class C
1	Bumthang	6,312.85	4,418.99	2,845.21
2	Chhukha	5,158.86	3,611.20	2,299.20
3	Dagana	4,815.13	3,370.59	2,167.74
4	Gasa	2,973.69	2,081.58	1,694.56
5	Ha	4,423.88	3,096.72	2,666.43
6	Lhuentse	5,314.44	3,720.11	2,671.61
7	Mongar	5,644.95	3,951.47	2,658.39
8	Paro	8,314.11	5,819.88	3,839.84
9	Pema Gatshel	5,646.32	3,952.42	2,287.77
10	Punakha	7,400.49	5,180.34	3,171.99
11	Samdrup Jongkhar	5,057.60	3,540.32	2,182.94
12	Samtse	6,085.76	4,260.03	2,112.80
13	Sarpang	5,318.84	3,723.19	2,043.97
14	Thimphu	17,412.53	12,188.77	3,955.82
15	Tsirang	5,630.16	3,941.11	2,142.94
16	Tashi Yangtse	5,545.12	3,881.58	2,637.52
17	Tashigang	6,034.64	4,224.25	2,679.37
18	Tongsa	5,433.20	3,803.24	2,262.54
19	Wangdue Phodang	6,595.22	4,616.66	3,373.06
20	Zhemgang	4,648.65	3,254.06	2,056.12

Note: Class A Land: Less than or equal to 2 KM from the municipal boundary.
Class B Land: More than 2 KM and less than or equal to 6 KMs from the municipal boundary.
Class C Land: More than 6 KMs from the municipal boundary.
Distance is horizontal distance in kilometers and the municipal boundary is as demarcated by the MoWHS.

source: Land Compensation Rates - 2009, Ministry of Finance

8.2 Review of Environmental Considerations for the Project

8.2.1 Consideration of the Natural Environment

In the JICA Master Plan (JICA/MP), most of the targeted sub-projects for distribution lines were formulated after the determination of on-grid or off-grid electrification using economic evaluations. The following three policies were adopted for environmental mitigation under the JICA/MP:

Avoid PAs and BCs as much as possible

These areas, including national parks, were designated as areas to be preserved by the Royal Government of Bhutan (RGoB). In the JICA/MP, PAs and BCs were given the highest priority for nature conservation.

- ✓ Apply covered conductors for distribution lines in PAs

If the line route cannot avoid traversing a PA or BC, covered conductors are adopted in the JICA/MP. Application of covered conductors allows for the reduction of the width of the right-of-way from 12 m to 9 m for 33 kV and from 9 m to 6 m for 11 kV. However, since covered conductors are costly, this increases the cost of the Project. The evaluation of line routes was weighed in favor of conservation of PAs and BCs. The area to be cleared for the right-of-way, as well as any impact on the PA, will therefore be minimized. Table-8.2.1 below shows the types of conductors to be adopted for mitigating the negative impacts in areas that are important for environmental conservation. The “Rules on Biological Corridors” as an Addendum to the Forest and Nature Conservation Rules (2007, MoA) states that, “Biological corridor shall mean an area set aside to connect one or more PAs, which shall be conserved and managed for the safe movement of wildlife. Priority for conservation in the BCs will be lower than that of the PAs but above Government Reserved Forest”. Although BCs are not technically included in PAs under the legislation, covered conductors for lines passing through a corridor were recommended. This was done to respect the function of environmental conservation in Bhutan.

Table-8.2.1 Type of Conductor to be Adopted for Distribution Line

Area Classification	Type of Conductor	Definition of Area Classification
Protected Area	Covered conductor	Declared National Park, Conservation area, Wildlife sanctuary, Nature reserve
Biological Corridor	Covered conductor	Not included in protected area. Area set aside to connect one or more protected areas
Other	Normal conductor	Not included in protected area. This area consists of forest, municipal and private area

Note: Prepared by JICA Preparatory Study Team based on “Rules on Biological Corridors” as an Addendum to the Forest and Nature Conservation Rules (2007, MOA), The Land Act of Bhutan : Sectoral Environmental Assessment Guideline for Transmission and Distribution Lines, NEC

- ✓ Locating distribution lines along roads

Constructing distribution lines in locations that have already been altered artificially (e.g., adjacent to existing roads) can avoid changing land use as well as topography. Actually, the Road Act requires securing 50 ft of clearance from the edge of main roads such as national highways, district roads, and feeder roads. In principle, distribution line projects have to observe the stipulations of the Road Act. A number of project sites for the targeted lines are planned to be located alongside roads that are not trafficable. In such situations, the route of lines may need to be adjusted when the route survey work is undertaken.

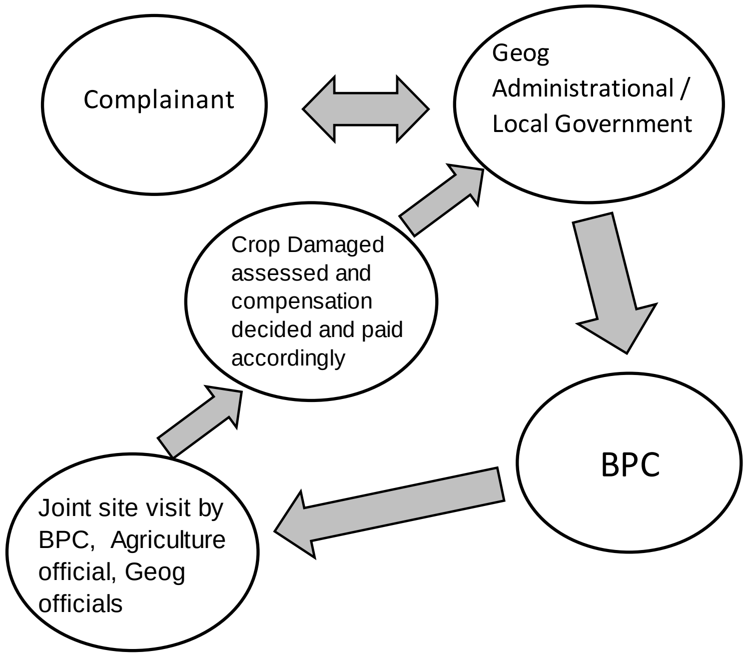
8.2.2 Consideration of the Social Environment

During the route surveys conducted by BPC, tshogpas or community representatives accompanied the field staff in order to provide information on social conditions such as households, institutes, religious sites and land use. Therefore, the route alignment and location of poles and other facilities have been chosen in order to minimize negative social impacts.

There are no houses or infrastructure that will be affected by the distribution line or location of poles and involuntary resettlement is not expected. The Project is also not expected to have any significant impact on the landscape or religious and cultural sites.

Even after the Project's location and design have been chosen to minimize negative social impact, some of the distribution lines will pass through and some poles will fall on private land and these may cause some damage to agricultural fields. BPC will pay compensation, when any crop damage caused by project implementation occurs.

Figure-8.2.1 shows the report and compensation scheme for crop damage.



Source: BPC

Figure-8.2.1 Compensation Scheme for Crop Damage

The procedures of compensation scheme for crop damage are as follows:

1) A farmer files a claim with gewog administrational / local government in a written document.
2) Gewog administrational / local government report the claim to BPC.
3) BPC, together with agriculture officials and gewog officials, conduct a site visit.
4) Crop damage is assessed and the amount of compensation is decided according to the Compensation Rates 2008 for cash crops / fruit trees, which are shown in Table-8.2.2.
5) BPC pays compensation to the complainant through gewog administrational / local government.
6) BPC receives the receipt from the complainant through gewog administrational / local government.

Table-8.2.2 Compensation Rates 2008 for Cash Crops / Fruit Trees

Compensation Rate – 2008								
Compensation rate for fruit trees / cash crops								
SN.	Crop	YRT*	0	1	2	3	4	5
1	Apple	5	484.00	784.00	1,384.00	1,684.00	1,984.00	4,105.00
2	Apricot	5	496.00	852.00	1,208.00	1,564.00	1,920.00	2,845.00
3	Areca nut	5	172.00	324.00	436.00	644.00	964.00	1,405.00
4	Avocado	5	424.00	744.00	1,064.00	1,344.00	1,704.00	2,280.00
5	Banana	2	114.00	174.00	174.00	174.00	174.00	174.00
6	Cardamom	5	29.60	33.60	37.60	41.60	45.60	77.00
7	Guava	5	372.00	576.00	780.00	984.00	1,188.00	1,490.00
8	Jackfruit	5	648.00	1,096.00	1,544.00	1,992.00	2,440.00	3,610.00
9	Lemon	5	356.00	756.00	1,156.00	1,356.00	1,456.00	1,820.00
10	Lime	5	292.00	452.00	612.00	772.00	812.00	1,065.00
11	Litchi	5	620.00	1,068.00	1,516.00	1,964.00	2,412.00	3,325.00
12	Mango	5	484.00	1,024.00	1,564.00	2,104.00	2,644.00	3,980.00
13	Olive	5	456.00	936.00	1,416.00	1,896.00	2,376.00	3,570.00
14	Orange	5	520.00	932.00	1,344.00	1,756.00	2,168.00	2,945.00
15	Papaya	4	180.00	225.00	270.00	285.00	380.00	380.00
16	Peach	4	372.00	651.00	930.00	1,119.00	1,664.00	1,692.00
17	Pear	5	392.00	712.00	1,032.00	1,352.00	1,672.00	2,490.00
18	Plum	5	420.00	776.00	1,132.00	1,488.00	1,844.00	2,750.00
19	Pomegranate	5	288.00	536.00	784.00	1,032.00	1,160.00	1,560.00
20	Pomelo	5	377.00	459.40	918.80	1,378.20	1,837.60	2,297.00
21	Tree Tomato	4	108.50	217.00	325.50	434.00	434.00	434.00
22	Bamboo	5	11.00	11.00	11.00	11.00	44.00	89.00
23	Walnut	5	708.00	1,112.00	1,516.00	1,920.00	2,324.00	3,410.00

* YRT is the time (years taken by a new seed / sapling to bear fruit or gain maturity

Source: Ministry of Finance

8.3 Review of the Initial Environmental Examination Report and Environmental Impact Assessment Reports

(1) Status of IEE/EIA

The IEE/EIA reports of the proposed Project in 19 dzongkhags were completed by ADB's PPTA study team. The IEE/EIA reports were prepared following ADB's Safeguard Policy Statement (2009) (SPS), the government's EIA guidelines, and related national policies and legislation. For the 11 dzongkhags that are Japanese official development assistance (ODA) loan target districts, a total of 15 IEE/EIA reports including additional feeder were submitted. NEC granted ECs for all dzongkhags in the Project in May 2010. The EIA report is only for Sarpang, while the rest of the dzongkhags have IEEs. The status of IEE/EIA reports is shown in Table-8.3.1. The copy of EC is shown in Appendix-F.1.

Table-8.3.1 Status of IEE/EIA

No	Dzongkhag	Type of study (EIA or IEE)	Feeder	Date when EIA/IEE was submitted to NEC	Clearance No.	Date of Environmental Clearance
1-1	Chukha	IEE	7	03/02/2010	NEC/ESD/1849/BPC/2010/7385	21/05/2010
1-2		IEE (Additional)	1	13/04/2010	NEC/ESD/1849/BPC/2010/7385	21/05/2010
2-1	Dagana	IEE	3	03/02/2010	NEC/ESD/1854/BPC/2010/7383	21/05/2010
2-2		IEE (Additional)	1	13/04/2010	NEC/ESD/1854/BPC/2010/7383	21/05/2010
3	Haa	IEE	3	03/02/2010	NEC/ESD/1847/BPC/2010/7398	21/05/2010
4	Paro	IEE	4	03/02/2010	NEC/ESD/1855/BPC/2010/7401	21/05/2010
5	Pemagatshel	IEE	5	03/02/2010	NEC/ESD/1848/BPC/2010/7384	21/05/2010
6	Punakha	IEE	1	03/02/2010	NEC/ESD/1851/BPC/2010/7386	21/05/2010
7	Samtse	IEE	10	03/02/2010	NEC/ESD/1847/BPC/2010/7399	21/05/2010
8	Sarpang	EIA	2	12/03/2010	NEC/ESD/1915/BPC/2010/7298	10/05/2010
9	Trongsa	IEE	1	11/02/2010	NEC/ESD/1864/BPC/2010/7302	21/05/2010
10-1	Tsirang	IEE	1	03/02/2010	NEC/ESD/1852/BPC/2010/7301	10/05/2010
10-2		IEE (Additional)	4	13/04/2010	NEC/ESD/1869/BPC/2010/7404	21/05/2010
11-1	Wangdue	IEE	8	03/02/2010	NEC/ESD/1846/BPC/2010/7304	21/05/2010
11-2		IEE (Additional)	1	16/04/2010	NEC/ESD/1846/BPC/2010/7304	21/05/2010
Total			52			

Note: Additional: Proposed feeder is additional to original feeders.

Souce : BPC

In case of Chuka, Dagana and Tshirang, some additional feeders were considered after the ADB's study as well as above table. These additional feeders will be proposed out of PAs and BCs. Thus, IEE reports for the additional feeder in these dzongkhags are under preparing as of November, 2010.

(2) Project Impact

IEE/EIA reports which were approved by NEC mention both positive and negative impacts.

1) Positive Impact

The Project will provide electricity to the rural areas. It will also benefit rural institutions including various government infrastructure and religious sites. RE will greatly improve the health, sanitation, well-being and quality of life of local communities due to their reduced exposure to smoke and kerosene products. Individual households will have the opportunity to increase their incomes by initiating or seeking new opportunities for alternative livelihoods. Communication will be greatly enhanced as mobile phones can be used. Schools and government offices will have access to information from the use of television, radio and the Internet.

2) Negative Impact

A major direct negative impact is caused due to the right-of-way (RoW) required when routes traverse through government reserve forests. The primary negative environmental impacts to the immediate area within the RoW include change in forest cover, effect on private land, impact on biodiversity, soil stability, water quality and erosion. Construction activities may cause temporary and limited damage to local flora and fauna. Other temporary impacts include the increase of fuel wood use, sanitation problems, workers' health and safety issues, waste generation and poaching of wildlife.

(3) Impact on Protected Area and Biological Corridor

In Sarpang and Wangdue dzongkhags, the proposed distribution lines are located in Jigme Singye Wangchuck National Park or BCs. Distribution lines of 34.2 km for Sarpang is located inside the PA or BCs while 17.3 km for Wangdue is located inside the PA. The feeder length in PAs is shown in Appendix-F.2.

The JICA Preparatory Survey Team (JPST) had a site survey to check the present status of the proposed line located in PAs and BCs. The results of the site survey are as follows:

- ✓ The proposed lines are basically chosen along the existing footpath/mule track.
- ✓ The proposed lines in the national park are almost along the river; people are already living in the site.
- ✓ The proposed lines in the BC have almost steep slopes; mule track in the forest.

There is a possibility that the Project will affect the PAs and BCs. However, people have already lived in the PAs and BCs and the proposed line is along the existing footpath and mule track. In the case of Wangdue, small vehicles can use the feeder road. In the case of Sarpang, the proposed lines pass through the abandoned motor road. As for the BC, though the proposed line crosses the corridors, the mule track is used as the main transport route for a long time. Therefore, the proposed distribution line would not cause significant impact on the PAs and BCs. Figure-8.3.1 shows the status of the PAs and BCs.

Figure-8.3.1 Status of Protected Areas and Biological Corridors

(4) Impact on Flora and Fauna

1) Tree Clearing

Tree clearing areas are shown in Table-8.3.2. Of the nine dzongkhags, the maximum cutting area is in Sarpang because the distribution line that passes through the forestry area is the longest. Project sites of RE are quite long but require very narrow areas. As most of the proposed distribution lines go along the existing footpath/mule track and nature in a wide area remains around the Project site, it seems that the new development will not result in the extensive loss of the natural environment. It is planned to minimize impact on the natural environment by mitigation measures such as avoiding unnecessary tree clearing.

Table-8.3.2 Tree Clearing Areas (RoW)

No	Dzongkhag	Forestry area (km)						
		Broadleaf forest	Conifer forest	Sokshing (trees for domestic use)	Tseri (Shifting Cultivation)	Scrub / Bush	Total Length	Clearing Area (km^2)
1	Chukha	28.4	0.0	0.0	0.0	3.5	31.9	0.382
2	Dagana	17.6	14.4	0.0	5.8	11.8	49.6	0.595
3	Haa	19.1	0.0	1.3	0.1	2.6	23.0	0.276
4	Paro	1.2	9.8	0.0	0.0	0.7	11.7	0.117
5	Pemagatshel	9.2	0.0	0.0	0.0	5.6	14.8	0.178
6	Punakha	9.0	0.0	0.3	0.0	0.5	9.8	0.118
7	Samtse	70.7	0.0	0.0	0.0	0.0	70.7	0.776
8	Sarpang	80.9	0.0	0.0	0.0	5.4	86.3	0.863
9	Trongsa	11.0	13.5	2.5	0.0	3.4	30.4	0.365
10	Tsirang	6.8	0.4	0.0	0.4	2.2	9.8	0.117
11	Wangduephodrang	18.4	6.8	0.0	0.0	1.2	26.4	0.283
Total		272.1	44.9	4.1	6.3	36.9	364.3	4.069

Note: Clearing Area is based on distribution line length and Right of Way (10m for 11kV and 12m for 33kV)

Clearing Areas of the additional feeders in Chukha, Dagana and Tsirang are not included in the above table .

Source: IEE/EIA report by ADB PPTA Study team

2) Important Species

The IEE/EIA reports show a list of flora and fauna, which were found or expected to be found along the feeders. The list of important species is shown in **Appendix-F.3**. Part of the Project site includes the habitat of species that are listed as important species in the Red List issued by IUCN and in Schedule 1 of the Forest and Nature Conservation Act of Bhutan.

Species recorded in the EIA reports were mostly from field surveys and interviews of forest staff and locals. Species in the IEEs were also same as the above but also from the management plans.

Interpretation of data that were obtained for species suggests the following:

- ✓ It is possible that some parts of the Project site are habitat areas of species that are listed as important species in the Red List issued by IUCN and in Schedule 1 of the Forest and Nature Conservation Act of Bhutan.
- ✓ Identified species of animals listed in the IUCN Red List can be regarded as species that inhabit forest areas.
- ✓ A relatively large number of mammals and birds was identified in the survey. However, species in categories that were not familiar to local people, such as insects and reptiles, were rarely recorded. The results of the survey very much depended on the perception and understanding of local people.

3) Impact on Flora and Fauna

Though it is difficult to determine the situation of flora and fauna by merely reviewing the results of the survey mentioned in IEE/EIA reports, an outline of the flora/fauna characteristics could be gained from the survey results. Examining this outline and the activities of RE, the following are concluded in this stage of the Project:

- ✓ The possibility of the existence of important animals recorded in the route survey is not high. Identified species of animals listed in the IUCN Red List are generally regarded as species inhabiting forest areas. Since most of the Project routes have been affected by human activities, such species are not assumed to use the Project routes as their main living area.
- ✓ Even if the important species recorded in the route survey are using the Project routes or areas surrounding the Project site, the frequency of use is not assumed to be as high as in their main living area.
- ✓ The Project will not prevent animal movement between different localities because, even in the project site, the Project structure to be developed will be composed of tall, thin poles and electricity lines drawn well above the ground surface.
- ✓ The Project was designed in the JICA/MP to protect the habitat environment of flora and fauna. The Project will not disturb important nature areas, such as those to be classified in the core zone of the zoning system for PAs.
- ✓ Route alignments were selected along existing farm roads and footpaths whenever possible. As these areas are already disturbed and degraded to an extent, it is unlikely to contain key species.
- ✓ Main land modification is pole foundation. Foundations have a standard size of 600 x 700 mm and dug to 1,900 mm for 11 or 33 kV lines. After excavation, concrete (mixed on site) is poured into the cavity to create a solid floor around 250 mm thick. Thus, the Project consists of no large land modification such as cutting and filling.

(5) Impact on Social Environment

The electrification project will provide significant socio-economic benefits including improved living conditions in households and facilities, improved health, increased incomes, improved communication and access to information. On the other hand, it may also cause some negative impacts on social environment. The following elements are major social issues:

1) Involuntary Resettlement

There are no houses or infrastructure that will be affected by the distribution line or location of poles, therefore, involuntary resettlement is not expected.

2) Land Use Change and Livelihood

Some distribution lines will pass through as well as some poles will fall on private land and these may cause an impact on agricultural land. However, most of the cultivation is for subsistence alone, and in terms of cash income, farmers will not be significantly affected even if a small portion of their land is required for pole erection.

3) Landscape and Cultural Heritage

Since the route alignment and location of poles and other facilities have been chosen to minimize negative social impacts, there will not be any cultural site along the alignment. No significant impact is expected on the landscape or on religious and cultural sites.

(6) Selection of the Category B Components

By reviewing the IEE/EIA reports finalized by the ADB PPTA study team and site survey, JPST screened the Project components by region and identified the potential Category B components in accordance with the JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002). According to the JBIC guideline, in principle, the Project components which do not cause negative impacts listed below will be selected as the candidate of the Project components for the new JICA Project "Category B":

- Large-scale logging,
- Involuntary resettlement, and
- Construction in the PAs or in habitats of rare species that require protection under domestic legislation, international treaties, etc.

Table-8.3.3 shows the check sheet arranged by the above items.

As for logging, the clearing areas show RoW without mitigation. Each clearing area is under 1.0 km^2 and the impact is mentioned above. There is no resettlement. Concerning both items, there are no significant adverse impacts on the environment.

On the other hand, in Sarpang and Wangdue dzongkhags, the proposed distribution lines are located in Jigme Singye Wangchuck National Park or BCs. It is very important to protect from negative impacts caused by construction implementation especially for sensitive areas. Thus, it is desirable to do appropriate and further mitigation which reduces the impact so that these feeders are selected as category B component.

Table-8.3.3 Considerable Category B Feeder Based on JBIC Guideline

	Dzongkhag Code	Dzongkhag	Feeder		Voltage	Right of Way Width	Distribution line detail length (Land use forest type)						Sensitive Characteristics			Sensitive Areas	Mark
					kV	m	Broadleaf (m)	Conifer (m)	Sokshing (m)	Tseri (m)	Scrub (m)	Total Length (km)	Forest Clearing Area (km²)	Clearing Area Dzongkhag (km²)	Affected Houses	Protected Area Biological Corridor	
1	B	Chukha	1	ARE3B1	33	12	7,420	0	0	0	1,220	8.64	0.104		0		○
2			2	ARE3B2	33	12	345	0	0	0	370	0.72	0.009		0		○
3			3	ARE3B3	33	12	122	0	0	0	0	0.12	0.001		0		○
4			4	ARE3B4	33	12	3,620	0	0	0	920	4.54	0.054		0		○
5			5	ARE3B5	33	12	1,400	0	0	0	0	1.40	0.017		0		○
6			6	ARE3B6	33	12	13,070	0	0	0	750	13.82	0.166		0		○
7			8	2LV line extentions	—	0	0	0	0	0	0	0.00	0.000		0		○
8		(Add)	7	ARE3B7	33	12	2,400	0	0	0	225	2.63	0.032	0.382	0		○
9	C	Dagana	1	ARE3C1	33	12	11,534	14,258	0	5,695	11,458	42.95	0.515		0		○
10			2	ARE3C2	33	12	0	85	0	70	0	0.16	0.002		0		○
11			3	ARE3C3	33	12	50	100	0	0	0	0.15	0.002		0		○
12		(Add)	4	ARE3C4	33	12	6,000	0	0	0	300	6.30	0.076	0.595	0		○
13	E	Haa	1	ARE3E1	33	12	4,700	0	850	100	400	6.05	0.073		0		○
14			2	ARE3E2	33	12	5,300	0	0	0	700	6.00	0.072		0		○
15			3	ARE3E3	33	12	9,100	0	400	0	1,450	10.95	0.131	0.276	0		○
16	H	Paro	1	ARE1H1	11	10	1,025	1,625	0	0	0	2.65	0.027		0		○
17			2	ARE1H2	11	10	30	5,370	0	0	0	5.40	0.054		0		○
18			3	ARE3H3 + Lvline	33	12	0	0	0	0	0	0.00	0.000		0		○
19			4	ARE1H4	11	10	100	2,800	0	0	700	3.60	0.036	0.117	0		○
20	I	Pemagatshel	1	ARE3I1	33	12	852	0	0	0	580	1.43	0.017		0		○
21			2	ARE3I2	33	12	1,600	0	0	0	2,700	4.30	0.052		0		○
22			3	ARE3I3	33	12	4,000	0	0	0	1,850	5.85	0.070		0		○
23			4	ARE3I4	33	12	2,700	0	0	0	516	3.22	0.039		0		○
24			5	LVline		0						0.00	0.000	0.178	0		○
25	J	Punakha	1	ARE3J1	33	12	3,822	0	0	0	522	4.34	0.052		0		○
26			2	ARE3J2	33	12	5,200	0	300	0	0	5.50	0.066	0.118	0		○
27	L	Samtse	1	ARE1L01	11	10	4,180	0	0	0	0	4.18	0.042		0		○
28			2	ARE1L02	11	10	3,070	0	0	0	0	3.07	0.031		0		○
29			3	ARE1L05	11	10	1,200	0	0	0	0	1.20	0.012		0		○
30			4	ARE1L06	11	10	17,440	0	0	0	0	17.44	0.174		0		○
31			5	ARE1L07	11	10	1,755	0	0	0	0	1.76	0.018		0		○
32			6	ARE1L08	11	10	911	0	0	0	0	0.91	0.009		0		○
33			7	ARE1L09	11	10	5,600	0	0	0	0	5.60	0.056		0		○
34			8	ARE1L10	11	10	2,000	0	0	0	0	2.00	0.020		0		○
35			9	ARE3L01	33	12	31,700	0	0	0	0	31.70	0.380		0		○
36			10	ARE3L02	33	12	2,800	0	0	0	0	2.80	0.034	0.776	0		○
37	M	Sarpang	1	ARE1M1	11	10	78,240	0	0	0	5,030	83.27	0.833		0	Jigme Singye Wangchuck National Park Bio I ogical Corridor	△
38			2	ARE1M2	11	10	2,670	0	0	0	400	3.07	0.031	0.863	0		○
39	Q	Trongsa	1	ARE3Q1	33	12	11,000	13,500	2,500	0	3,400	30.40	0.365	0.365	0		○
40	R	Tsirang	1	ARE3R1	33	12	150	400	0	400	800	1.75	0.021		0		○
41		(Add)	2	ARE3R2	33	12	1,630	0	0	0	0	1.63	0.020		0		○
42			3	ARE3R3	33	12	3,000	0	0	0	500	3.50	0.042		0		○
43			4	ARE3R4	33	12	1,000	0	0	0	460	1.46	0.018		0		○
44			5	ARE3R5	33	12	1,000	0	0	0	450	1.45	0.017	0.117	0		○
45	S	Wangdue	1	ARE3S1	33	12	0	1,964	0	0	0	1.96	0.024		0		○
46			2	ARE1S2	11	10	3,932	0	0	0	0	3.93	0.039		0		○
47			3	ARE3S3	33	12	2,461	0	0	0	0	2.46	0.030		0		○
48			4	ARE3S4	33	12	0	2,800	0	0	200	3.00	0.036		0		○
49			5	ARE3S5	33	12	0	72	0	0	0	0.07	0.001		0		○
50			6	ARE3S6	33	12	0	128	0	0	0	0.13	0.002		0		○
51			7	ARE3S7	33	12	0	1,826	0	0	0	1.83	0.022		0		○
52		(Add)	8	ARE1S8	11	10	12,000	0	0	0	1,000	13.00	0.130	0.283	0	Jigme Singye Wangchuck National Park	△
												364.273	4.069	4.069	0		

Note : Forest Clearing Area ; Calculation value by Transmission Line Length and wedthe of Right of Way

○ ; Proposed Feeder selected to considerable Category B by JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002).

△ ; In principle, it has category A mutter in JBIC Guideline 2002. However, it would be judged by an examination based on the site present situation.

Distribution detain and Clearing Area of the additional feeders in Chuka, Dagana and Tshirang are not included in the above table.

Source: IEE/EIA report by ADB PPTA

8.4 Preparation of an Environmental Management Plan

(1) Environmental Mitigation Measures

1) Prepared Mitigation Measures in IEE/EIA

IEE/EIA report described the mitigation measures, as shown in Table-8.4.1.

Table-8.4.1 Environmental Mitigation Measures (IEE/EIA Reports)

Negative Impacts	Mitigation measures
Construction	
Dust may blow from areas cleared of vegetation in RoW	Leave a covering of grass & other low vegetation in RoW
Risk of forest fires if cut vegetation is burnt	Leave cut material to rot down in situ and do not burn; Dispose of trees as required by NRDCL
Felling of trees may degrade forest habitat	Follow standard BPC procedures and practises in clearing ROW
Effect on local drainage, soil erosion and soil stability	Locate poles at a minimum distance of 30 m from rivers, and construct these on stable ground
Workers could damage species & habitats outside RoW	Only fell trees that have been marked by Forestry staff; Prohibit hunting or fishing by workers and enforce strictly; Locate labour camps where no forest clearance is needed
Excavation may damage water pipes	Consult community to identify and avoid infrastructure
Work in villages may create noise, dust & impede access	Inform communities of work in advance; Identify sites of local significance; locate no poles nearby; Consult custodians of facilities (monasteries, nunneries, schools, clinics, etc) and avoid working at sensitive and religious times.
Economic benefits if local people are employed in Contractor's workforce	Employ as many local residents as possible in workforce
Importing foreign workers can cause environmental and social problems at labour camps and in host community	Provide imported workers with housing and ample toilets with proper drainage and treatment for sewage. Solid waste should be collected and buried offsite. Workers must be instructed on required behavior and prohibited from hunting and fishing. After project completion, camps must be cleaned up and restored.
Diseases can be introduced into host communities from social and sexual contact with imported workers	Initial screening of workers for HIV/AIDS, TB, malaria, swine flu, etc.; Facilitate access to the nearest Health facility for check up; Raise worker/community awareness of risks of socially & sexually transmitted disease; Practical measures, e.g. free condoms for workers
Workers and villagers are at risk from accidents on site	Prepare and implement a site Health and Safety Plan that includes measures to: - Exclude the public from all construction sites; - Ensure that workers use Personal Protective Equipment; - Provide Health & Safety Training for all personnel; - Keep accident reports and records; - Inform local communities about the work and danger
Operation	
People cannot use new electrical machines during power cuts so income may suffer	BPC should repair faults quickly and effectively
Consumers are at risk of electrocution if they do not understand the dangers of electricity	Train and supervise BPC field operatives to ensure that they check house wiring carefully and reject if deficient; Public education to raise villagers' awareness of dangers of electricity and how to utilise the system safely.
BPC workers are at risk if they do not follow BPC procedures when clearing RoW or repairing faults	Follow BPC O&M and H&S manuals and revise these manuals if necessary to increase safety of workers; Regular training of BPC workers to raise awareness of dangers; Improve supervision of field workers; Regular management reviews of safety record, with remedial action where necessary
People will not be very tolerant of power cuts once they become used to the benefits of electricity	As above: repair faults quickly and effectively; Conduct system maintenance regularly and diligently

Note: National Resources Development Corporation Limited (NRDCL)

Source: IEE/EIA report by ADB PPTA

2) Additional Mitigation Measures

The JPST proposes two additional mitigation measures for distribution lines in PAs and BCs. The first proposal is to adopt covered conductors for distribution lines in PAs and BCs. This will reduce the clearance area that is needed for safety reasons. The second proposal is the application of a mid-green paint for distribution poles, which will be constructed at the entrance of PAs in Wangdue.

In the case of Phase 1, covered conductors have already been used in PAs and the Project is under construction as category B.

BPC staff and JPST briefly discussed about the additional proposals. BPC opined that adopting covered conductors will be acceptable based on the experience in PAs. As for the colored poles, BPC thought to consider adopting it when there are no technological problems at all.

(2) Environmental Monitoring Plan and Organization Responsible for Implementation

Environmental issues will be coordinated by the BPC Environmental Unit, which will ensure that all subprojects comply with national environmental safeguards. The Environmental Monitoring Plan (EMP) involves observations and surveys to be conducted during construction and operation to ensure that mitigation measures are provided and that they protect the environment as intended. Construction monitoring will be conducted by the Rural Electrification Department (RED) field offices while monitoring during operation will be coordinated by the Distribution and Customer Services Department (DCSD) of BPC.

During the construction stage, contractors employed to build the infrastructure shall be fully responsible for all mitigation activities. Responsibility will be assigned via the contracts through which they have been appointed (prepared by RED during the detailed design stage), so they will be legally required to undertake the necessary actions. Mitigation during system operation is the responsibility of the Electricity Services Divisions (ESD), which is the agency responsible for maintaining the system in good working condition.

An environmental officer (EO) will be responsible for implementing the EMP during the construction stage and reporting the results to RED with recommendations for remedial action if measures are not being provided or protecting the environment effectively.

The IEE/EIA report described the monitoring plan, as shown in Table-8.4.2. The EMP describes the following: (i) mitigation measures, (ii) location, (iii) measurement method, (iv) frequency of monitoring, and (v) responsibility. These are judged to be appropriate. In principle, the executing agency should be responsible for environmental monitoring. However, some agencies such as NEC and DoF have specific responsibilities for their related sectors in Bhutan. Although there is no regulatory requirement to report, management and monitoring will be done appropriately to keep the conditions of EC.

Table-8.4.2 Environmental Monitoring Plan

Mitigation Activities	Location	Responsibility	Monitoring Method	Monitoring Frequency	Responsible for Monitoring
Construction					
Leave cut material to rot down in situ and do not burn	MV route	Contractor	Site observations	Monthly	BPC EO
Follow BPC standard procedures and practices in clearing ROW	MV route	Contractor	Site observation; villager survey	3 months	BPC EO
Only fell trees that have been marked by Dept of Forests	MV route	Contractor	Site observations	Monthly	BPC EO
Locate poles at a minimum distance of 30 m from rivers, and construct these on stable ground	MV route, pole location	Contractor	CC records; site observation	3 months	BPC EO
Create awareness among workers on importance of wildlife and habitats	MV route	Contractor	CC records; worker survey	3 months	BPC EO
Locate labour camps where no forest clearance is needed	All sites	Contractor	CC records; site observation	3 months	BPC EO
Identify sites of local significance; locate no poles nearby	LV lines	Contractor	Site observation; villager survey	Monthly	BPC EO
Consult custodians of facilities: avoid working at sensitive times	LV lines	Contractor	Site observation; village survey	Monthly	BPC EO
Employ as many local residents as possible in workforce	All sites	Contractor	CC records; worker survey	3 months	BPC EO
House imported workers in adequate accommodation, including: - solid waste collected daily and buried offsite; - workers trained in required behaviour in host community; - prohibition of hunting and fishing by camp occupants	All sites	Contractor	Site observation; worker survey	Monthly	BPC EO
Prepare/implement site Health and Safety Plan that include: a) excluding the public from construction sit, use of Personal Protective Equipment, Providing Health and Safety Training for staff, recording all accidents and Informing local communities about the work and dangers.	All sites	Contractor	Site observation; CC records	3 months	BPC EO
Operation					
Maintain system regularly; repair faults quickly and effectively	All sites	ESD	ESD records; villager survey	Annually,	BPC
Train & supervise BPC field operatives to ensure that they check house wiring and reject if deficient	New users	ESD	BPC records; villager survey	Annually,	BPC
Public education: raise villager awareness of dangers of electricity	New users	ESD	BPC records; villager survey	Annually,	BPC
Follow BPC O&M and H&S manuals and revise if necessary	ESD	ESD	BPC records	As needed	BPC
Regular training of BPC workers on dangers & working procedures	ESD	ESD	BPC records; worker survey	Annually,	BPC
Improve supervision of field workers	ESD	ESD	BPC records; site observations	3 months	BPC
Regular management reviews of safety, with remedial action	ESD	ESD	BPC records	3 months	BPC
LONG-TERM SURVEYS					
Monitor scheme benefits, adequacy of service, identify deficiencies	All sites	BPC	Customer satisfaction survey	Annually,	BPC

Note: ESD-Electricity Services Division (BPC), BPC EO -BPC Environmental Officer, CC-Construction Contructor

Source: IEE/EIA report by ADB PPTA

8.5 Social Development

8.5.1 Household Socioeconomic Survey

(1) Non-electrified Household Survey

ADB PPTA conducted a socioeconomic survey of households which have not yet received any electricity as of now and which are proposed to be provided with electricity under the RE Project by 2013. The study's principal objective was to assess the socioeconomic situation of the sample households and study the baseline situation of the population within the Project areas.

The framework of ADB Household Survey is summarized in Table-8.5.1.

Table-8.5.1 Framework of ADB Household Survey

Items	Contents
Survey Area	18 Dzongkhags (Thimphu, Paro, Haa, Punakha, Wangdue Phodrang, Chukha, Samtse, Dagana, Tsirang, Sarpang, Zhemgang, Trongsa, Mongar, Lhuntse, Trashi Yangtse, Trashigang, Pemagatshel and Samdrup Jongkhar)
Survey Method	Household visits and interview using structured questionnaires
Type of Households	(i) non-electrified households targeted for the on-grid electricity supply, (ii) non-electrified households targeted for the off-grid solar home lighting system installation, and (iii) non-electrified households with the potential for a biogas plant
Type of the Survey	Sample survey (A 20% sample size of the total number of households)
Number of samples	1,967 households (1,609 housesholds in 18 Dzongkhags for on-grid connection, 358 households in 8 Dzongkhags for SHLS)

Prepared by JICA Study Team based on Rural Renewable Energy Development Project BHU-7318 Social Economic Analysis (ADB PPTA Consultants Team, 2010)

(2) Electrified Household Survey

The JICA Study Team conducted a supplemental socioeconomic survey. The objectives of the survey are as follows: (a) to obtain data comparable with the result of the ADB Household Survey, and (b) to obtain energy price data for economic evaluation. The target of the survey was households which have already been provided with electricity.

The framework of the supplemental socioeconomic survey is summarized in Table-8.5.2.

Table-8.5.2 Framework of the Supplemental Socioeconomic Survey

Items	Contents
Survey Area	6 Dzongkhags (Samtse, Thimphu, Trashigang, Punakha, Zhemgang, Mongar)
Survey Method	Household visits and interview using structured questionnaires
Type of Households	Electrified households
Type of the Survey	Sample survey
Number of samples	150 households

Prepared by JICA Study Team

8.5.2 Socioeconomic Findings

(1) Overview of Non-electrified Households

The average figures of major survey results on all sampled non-electrified households that were surveyed (1,967 households) are summarized in Table-8.5.3. The same figures by dzongkhag are provided in **Appendix-G**.

Table-8.5.3 Overview of Non-Electrified Households (1/2)

Major Items		Total Average
Average Number of Family Members		5.3 Persons / Household
Average Annual Household Income		21,990 Nu.
Average Monthly Household Expenditures		Food (908 Nu.), Clothing (360 Nu.), Travel (269 Nu.), Housing (2,097 Nu.), Religious ceremonies (460Nu.), Entertainment (168Nu.)
Average Holding of Land		4.7 Acre
Major Use of Alternative Energies		Kerosene (Lighting: 94.5%, Cooking: 16.0 ％ , Heating:12.2%), Diesel Oil (Machinery: 2.5%), Candle (Lighting: 6.3%), Dry Cell Battery (Radio: 57.7%, Lighting: 7.2%), LPG (Cooking: 11.2%), Firewood (Cooking: 99.8 ％ , Heating:92.0%, lighting 24.4%).
Use of Alternative Energies - Kerosene - Dry Cell Battery	Monthly Amount of Paying for Kerosene	Less than 100 Nu.(66.3%), 101 - 500 Nu.(32.1%), 501 - 1000 Nu.(1.6%), N/A.(N/A),
	Monthly Traveling Time for Getting the Kerosene Replaced	1 hour (9.9%), 2 hours (11.0%), 3 to 5 hours (16.8%), More than 5 hours (62.2%)
	Monthly Amount of Paying for Batteries	Less than 100 Nu.(89.2%), 101 - 500 Nu.(8.9%), 501 - 1000 Nu.(0.4%), N/A (1.6%),
	Monthly Traveling Time for Getting Batteries	1 hour (16.6%), 2 hours (13.2%), 3 to 5 hours (16.8%), More than 5 hours (53.4%)
Use of Alternative Energies - LPG	Monthly Amount of Paying for LPG	Less than 100 Nu.(1.4%), 101 - 500 Nu.(6.4%), 501 - 1000 Nu.(3.3%), N/A (89.0%),
	Traveling Time for Getting the LPG Replaced	1 hour (6.0%), 2 hours (12.0%), 3 to 5 hours (18.4%), More than 5 hours (63.6%)

Table-8.5.3 Overview of Non-Electrified Households (2/2)

Major Items			Total Average
Use of Alternative Energies - Firewood	Average Daily Usage of Firewood	Volume	1.7 Backload/day
		Monetary Value	22.5 Nu./day
	Average Time for Collecting Firewood per day (hours)		2.3 hours/day
	Proportion of Households with Purchasing Firewood		4.1%
	Monthly Amount of Paying for Firewood		Less than 100 Nu.(63.0%), 101 - 500 Nu.(27.2%), 501 - 1000 Nu.(6.2%), More than 1001 Nu.(3.7%),
	Proportion of Households with Paying for Royalty		65.2%
	Annual Amount of Paying for Royalty to cut trees		Less than 100 Nu.(59.3%), 51 - 100 Nu. (6.9%), 101 - 150 Nu.(23.8%), 151 - 200 Nu.(7.1%), More than 201 Nu.(0.8%)
Willingness to Pay	Maximum Amount the Household Would Pay		Less than 100 Nu.(46.6%), 101 - 200 Nu. (32.3%), 201 - 300 Nu.(8.8%), 301 - 400 Nu. 4.3%), 401 - 50 Nu. 2.5%), More than 501 Nu. 5.5%)

Major Items	Total Average
Electric Appliances Wishing to Purchase	Electrical bulbs (80.88%), Electrical kettle (4.93%), Rice cooker (83.07%), Electric mill (8.44%), Curry cooker (78.39%), Refrigerator (24.66%), Water boiler (70.56%), TV (47.48%), Electric iron (8.29%), Radio/cassette player (37.26%), Electric fan (14.84%), Electric room heater (17.29%), Electric stove (5.59%), Others (electrical drills/plainer) (0.76%)

Source: Household Socioeconomic Survey Preparing the Rural Renewable Energy Development Project (ADB PPTA Consultants Team, 2010)

(2) Overview of Electrified Households

The average figures of major survey results on sampled electrified households that were surveyed (150 households) are summarized in Table-8.5.4. The same figures by dzongkhag are provided in **Appendix-G**.

Table-8.5.4 Overview of Electrified Households (1/3)

Major Items	Total Average
Average Number of Family Members	4.8 Persons / Household
Average Annual Household Income	162,654 Nu.
Average Monthly Household Expenditures	Food (1,999 Nu.), Clothing (323 Nu.), Electricity (winter: 174 Nu., summer: 130 Nu.), Travel (626 Nu.), Housing (2,357 Nu.), Religious ceremonies (1,213Nu.), Entertainment (228Nu.)
Average Holding of Land	2.7 Acre
Major Use of Alternative Energies	Electricity (Lighting: 100%, Cooking: 99%), Kerosene (Lighting:24%), Diesel Oil (Milling: 7%), Candle (Lighting: 79%), Dry Cell Battery (Lighting: 53％, Radio: 9%), LPG (Cooking: 71%), Firewood (Cooking: 43％, Heating: 32%).

Table-8.5.4 Overview of Electrified Households (2/3)

Major Items			Total Average
Use of Alternative Energies - Kerosene - Diesel Oil - Candle - Dry Cell Battery	Average Interval of Purchasing		Kerosene (111 days), Diesel Oil (98 days), Candle (83 days), Dry Cell Battery (56 days).
	Average Volume of Purchasing at a Time		Kerosene (5.8 Litters), Diesel Oil (25.5 Litters), Candle (5.8 Pieces), Dry Cell Battery (3.0 Pieces).
	Average Unit Price		Kerosene (13 Nu./Litter), Diesel Oil (33 Nu./Litter), Candle (6 Nu./Piece), Dry Cell Battery (14 Nu./Piece).
	Average Time by Mode of Transportation	Walking	Kerosene (0.3 hours), Diesel Oil (N/A), Candle (0.2 hours), Dry Cell Battery (0.2 hours).
		Bus & Taxi	Kerosene (0.9 hours), Diesel Oil (1.5 hours), Candle (1.8 hours), Dry Cell Battery (1.5 hours).
		Asking Someone for a ride	Kerosene (N/A), Diesel Oil (N/A), Candle (N/A), Dry Cell Battery (N/A).
	Average Fare by Taxi & Bus		Kerosene (50 NU), Diesel Oil (43 Nu.), Candle (80 Nu.), Dry Cell Battery (90 Nu.).
Use of Alternative Energies	Average Holding of LPG Cylinder		14kg（1.8 Cylinders）,4kg（N/A）
	Average Frequency of Refilling LPG		LPG 14kg (Every 2.1 months), LPG 4kg

Major Items			Total Average
- LPG			(N/A).
	Average Amount Paid for Refilling		LPG 14kg（421 Nu.）,LPG 4kg（N/A）
	Average Traveling Time		Walking (0.2 hours), Bus & Taxi (1.2 hours), Asking Someone for a ride (1.1 hours).
	Average Fare by Taxi & Bus		70Nu.
Use of Alternative Energies - Firewood	Average Volume of Current Stock		Backload (23.4 Units), Cubic Feet (N/A), Truckload (0.7 Units).
	Average Duration Current Stock will last		Winter (55 days), Summer (58 days).
	Average Daily Usage of Firewood		Winter (0.43 Backload/day), Summer (0.40 Backload/day).
	Use of Firewood	Winter	Cooking (21%), Heating (28%), Lighting (N/A), Others (53%).
		Summer	Cooking (24%), Heating (N/A), Lighting (N/A), Others (63%).
	Ways of Getting Firewood		Purchasing (15.3%), Hiring a wood gatherer (42.7%), Family Members (30.7%).
	Average Frequency of Purchasing / Hiring Someone to gather / Collecting by Family Members		Purchasing (Every 1.3 Year), Hiring (Every 11.8 months), Family Members (8.6 days out of Every 6.8 months).
	Purchasing Firewood	Average Purchasing Volume	1.0 Truckload
		Average Amount Paid	6,422 Nu.
		Average Time by Mode of Transportation	Walking (0.27 hours), Bus & Taxi (2.45 hours), Asking Someone for a ride (0.00 hours)
		Average Fare by Bus & Taxi	56 Nu.

Table-8.5.4 Overview of Electrified Households (3/3)

Major Items				Total Average
Use of Alternative Energies - Firewood	Collecting Firewood by Hiring Someone or Family Members	Average Number of Hiring Someone / Collecting by Family Members		Hiring (6.6 Persons), Family Members (5.0 Persons).
		Average Duration of Hiring Someone / Collecting by Family Members		Hiring (4.8 days), Family Members (8.6 days).
		Average Volume of Collection	Hiring Someone	Backload (160.8 Units), Truckload (0.9 Units).
			Family Members	Backload (91.0 Units), Truckload (1.0 Units).
		Average Paid Amount for Hiring Someone to gather		140.6 Nu./day/Person
Use of Electricity	Amount of Monthly Electricity Bill	Average Amount		Winter (173.7 Nu.), Summer (130.4 Nu.).
		Maximum Amount		Winter (920.0 Nu.), Summer (720.0 Nu.).
	Actual Amount of Monthly Electricity Bill	Average Amount		March 10 (146.8 Nu.), December 09 (187.6 Nu.), September09 (156.4 Nu.), June 09 (124.4Nu.),
		Maximum Amount		March10 (1000 Nu.), December09 (1024 Nu.), September09 (1500 Nu.), June09 (900 Nu.),
	Average Payment Interval of Electricity Bills.			1.04 days
	Average Traveling Time			Walking (0.23 hours), Bus & Taxi (0.97 hours), Asking Someone for a ride (1.02 hour).

Major Items		Total Average
	Average Fare by Bus & Taxi	50 Nu.

Source: Electrified Household Survey (JICA Study Team, 2010)

8.5.3 Socioeconomic Evaluation

(1) Socioeconomic Benefits of Electrification

Electrification will bring significant socioeconomic benefits to rural communities and it is expected to improve the quality of life of people living in these communities. The benefits that will be achieved through RE are as follows:

improved education, as better lighting will allow students to study for longer hours;

- ✓ improved health since respiratory and eye ailments caused by smoke emitted from firewood and kerosene are reduced;
- ✓ promotion of communication technologies such as mobile phones and Internet facilities;
- ✓ establishment of small and cottage industries such as food processing, handicrafts, etc.;
- ✓ promotion of income generating activities which will be possible to do even at night;
- ✓ facilitation of doing household chores by using electrical appliances and increase in productivity;
- ✓ reducing the amount of time and money used in collecting firewood;
- ✓ increase of security at night;
- ✓ decrease in rural-urban migration; and
- ✓ promotion of social visits and interaction.

Table-8.5.5 below shows the perceptions of benefits of households that are to be electrified.

Table-8.5.5 Perceptions of Benefits from Electricity

Perceived impacts \ Degree of belief	Percent of households			
	Very much	A little	Not at all	Don't know
The village/house will be better maintained in term of cleanliness	85.71 %	14.03 %	0.10 %	0.153 %
There will be better houses coming up in the villages	61.72 %	34.06 %	1.63 %	2.593 %
There will be more kinds of small businesses	48.45 %	44.08 %	3.81 %	3.66 %
There will be more migrants coming back to the village	38.18 %	45.30 %	7.88 %	8.643 %
There will be less youth migration to cities	32.33 %	41.33 %	16.22 %	10.12 %
Social life in the village will improve	80.68 %	16.68 %	0.66 %	1.983 %
It will be safer at night in the village	85.10 %	12.51 %	1.42 %	0.966 %
New services and commercial activities will be available in the village	48.75 %	41.38 %	2.29 %	7.575 %
With electricity there will be more opportunities to employment and training.	49.16 %	39.50 %	2.85 %	8.49 %
After receiving electricity/solar lights smoke-related diseases (cough, eye itch, tearful eyes) will be reduced	78.14 %	18.71 %	1.22 %	1.932 %
After receiving electricity/solar lights	82.71 %	14.59 %	1.12 %	1.576 %

Perceived impacts \ Degree of belief	Percent of households			
	Very much	A little	Not at all	Don't know
children will spend more time at home in studying which will improve their academic results.				
More information will be available through media	79.77 %	18.81 %	1.02 %	0.407 %
Burden on women will decrease	77.38 %	18.86 %	1.98 %	1.779 %
Service delivery for women and child health care will improve	75.09 %	21.10 %	1.93 %	1.881 %
More women will be enrolled in NFE	55.92 %	32.64 %	4.88 %	6.558 %

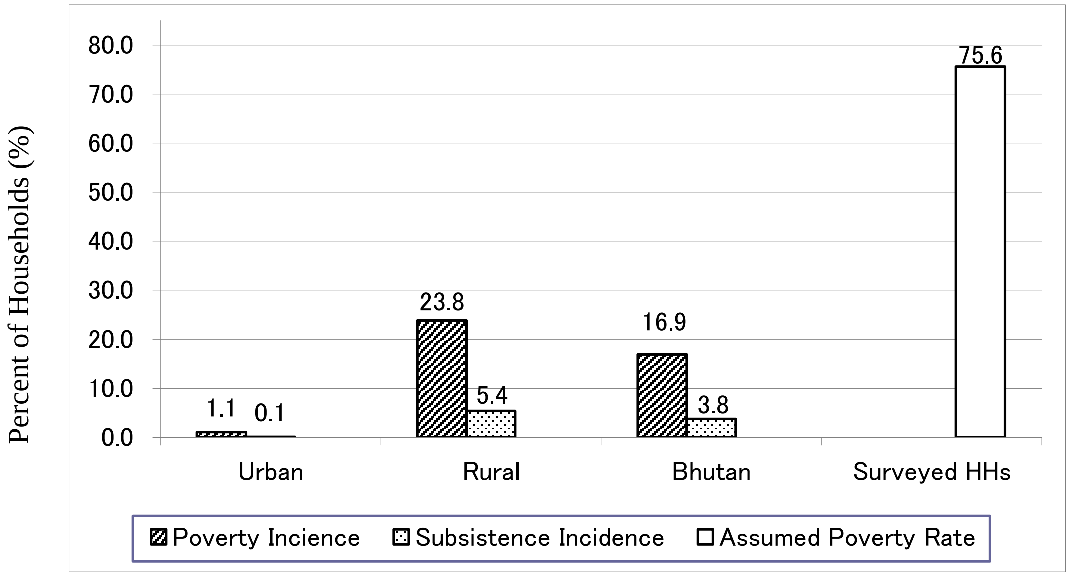
Source: Rural Renewable Energy Development Project BHU-7318 Social Economic Analysis (ADB PPTA Consultants Team, 2010)

(2) Impact on the Poor

In 2007, the total poverty line in Bhutan was set at Nu.1,096.94 per person per month and the food poverty line was set at Nu.688.96 per person per month. Households (and their members) which consume (in real terms) less than the total poverty line are considered poor and households (and their members) which consume (in real terms) less than the food poverty line are considered subsistence poor. Figure-8.5.1 illustrates subsistence and poverty incidence in terms of the percentage of households across urban and rural areas as well as the poverty rate of surveyed households. The percentage of poor households in the rural area is estimated at 23.8%.

The poverty line explained above was calculated based on food consumption and non-food allowance, which also takes into account the imputed value. The ADB Household Survey data included income and expenditure of major items, but it did not include food consumption for self-sufficiency. Therefore, the result of the household survey cannot directly be compared with the poverty line. In order to estimate the poverty rate of the targeted households of the Project, the JPST applied the same methodology used by the JBIC SAPROF Study Team and the assumed poverty line was estimated to be about Nu.3,026/household/month[1]. When calculated from the data obtained from the ADB Household Survey, 75.6% of non-electrified households that were targeted for on-grid electricity supply are below this assumed poverty line. As shown in Figure-8.5.1, this percentage is much higher than the poverty rate of households in rural Bhutan.

1 Ninety-five percent of the food poverty line can be counted as self-sufficient food consumption in non-electrified households. The value of self-sufficient food should be considered to be a plus in the income of households. Thus, this amount was subtracted from the poverty line as “assumed poverty line” to make the poverty line compatible with the Household Survey data. The average number of people in a targeted non-electrified household for on-grid electricity supply is 5.2. Accordingly, the assumed poverty line is (1096.94 - 688.96 x 0.95) Nu./month/capita x 5.2 = 2,301.



Source: Poverty Analysis Report 2007 and Household Socioeconomic Survey Preparing the Rural Renewable Energy Development Project (ADB PPTA Consultants Team, 2010)

Figure-8.5.1 Poverty and Subsistence Households in Bhutan

As stated above, electrification will bring in a lot of positive socioeconomic impacts and households will have the opportunity to increase their incomes. Therefore, the RE Project can make a significant contribution to the reduction of poverty in Bhutan.

However, it should be noted that people living below the poverty line are not necessarily considered vulnerable in Bhutan's case. Vulnerability is mainly due to the lack of access to essential services (such as education and health care) rather than the lack of income.

(3) Impact on Women

The benefits of electrification are basically delivered equally to everyone. However, the degree of impact sometimes differs between men and women. For example, the provision of electricity will reduce indoor smoke pollution and will improve the health condition of village people by reducing the chances of respiratory and eye ailments. These kinds of ailments are more common in women, children and the elderly since these groups remain indoors more than men. In such a case, electricity benefits women more than men.

Table-8.5.6 shows the expected benefits of electricity on men and women living in non-electrified households. In 84% of surveyed households, it is expected that women will benefit because doing household chores becomes easier. As shown in Table-8.5.5, 77% of non-electrified households expect that the burden on women will decrease.

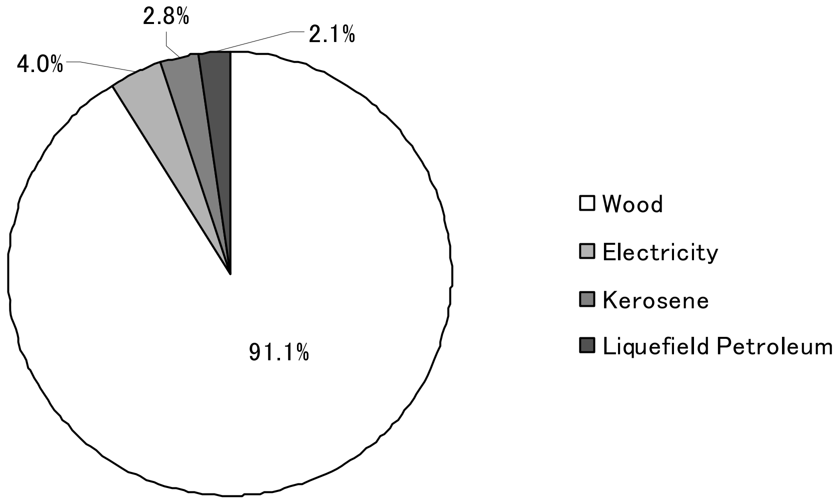
Table-8.5.6 Benefits of Electricity on Men and Women

Men	
Men can do productive work even after dark	45.20 %
Men can help household chores while women do productive work	23.84 %
Others (men can help look after kids)	1.58 %
Women	
Women can weave for longer hours	55.26 %
Doing household chores becomes easier for women	84.09 %
Children can be better looked after	46.01 %
Women can keep the houses more clean	49.92 %
Others (cooking becomes easier)	4.98 %

Source: Rural Renewable Energy Development Project BHU-7318 Social Economic Analysis (ADB PPTA Consultants Team, 2010)

(4) Reduction of Firewood Consumption

In Bhutan, the major energy source for households is firewood. Figure-8.5.2 illustrates energy consumption in the residential sector by type of fuel. The total energy consumption is 190,406 TOE and about 90% of the energy demand is met by firewood.

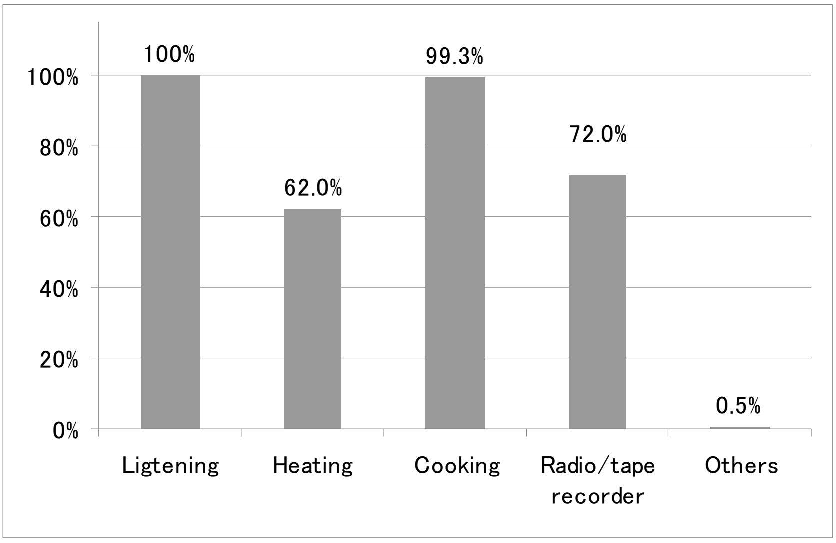


Source: Bhutan Energy Data Directry 2005, TERI

Figure-8.5.2 Energy Consumption (by Fuel) in the Residential Sector

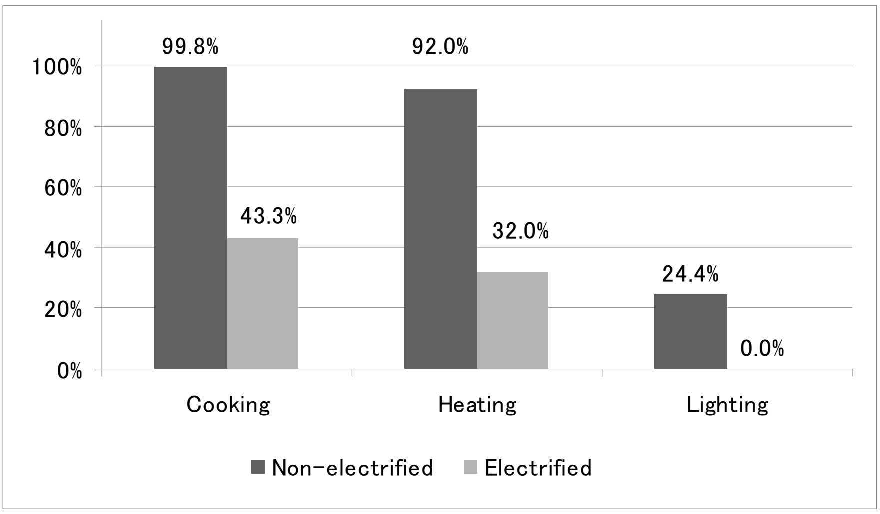
Figure-8.5.3 illustrates the percentage of households using electricity by end-use and Figure-8.5.4 shows the percentage of households using firewood by end-use. Electricity can substitute for alternative energy used for lighting, cooking and heating. In non-electrified households, the main energy used for lighting is kerosene (94.5% of households) and firewood is the second largest energy source for lighting (24.4%). Firewood is the largest energy source for cooking (99.8%) and for heating (92.0%). In electrified households, only 43% use firewood for cooking and 32% for heating. The consumption of firewood will decrease once households are electrified.

The reduction of firewood consumption is one of the major objectives of electrification. It can mitigate deforestation, smoke-related health problems (eyes and lung ailments), and the household burden of firewood collection.



Prepared by JICA Study Team based on the JICA Households Survey

Figure-8.5.3 Use of Electricity by End-use



Prepared by JICA Study Team based on the JICA Households Survey and ADB Households Survey data

Figure-8.5.4 Use of Firewood by End-use

8.5.4 Recommendation for Facilitating Household Access to Electricity

(1) Cost for Households to Obtain Electricity

The necessary costs to be supported by the customer for a new electricity connection include the following: i) in-house wiring cost, ii) deposit for meter security, and iii) energy security cost.

BPC is responsible for providing service up to the meter in terms of line installation. Consumers have to cover their own in-house wiring costs including wiring, accessories and electrician fee. The in-house wiring would cost about Nu.5,000 or more.

Regarding the deposit for meter security, the cost is determined by phase. It is shown in Table-8.5.7 below.

Table-8.5.7 Deposit for Meter Security

Phase	Price (Nu)
Single Phase	250
Three Phase	850

Source: BPC

Households will also bear the energy security cost. It is determined by phase and capacity of energy meters. Table-8.5.8 shows the cost for energy security by type.

Table-8.5.8 Energy Security Cost

Phase	Rating in Ampere (A)		Unit Price	Cost for Energy Security
	From	To	(Nu/Ampere)	(Nu)
Single	2.5	10	12	120
	5	20		240
	10	40		480
	10	60		720
Three	5	30	36	1,080
	10	60		2,160

Source: BPC

(2) Ability and Willingness to Pay of Households for a New Electricity Connection

During the household survey, households targeted for on-grid connection were asked if they had the ability and willingness to pay for the cost of a new electricity connection.

Regarding the in-house wiring, 94.1% of the surveyed households answered that they can afford Nu.5,000 for in-house wiring. Their willingness to pay for in-house wiring is shown in Table-8.5.9.

Regarding the deposit for meter security, 2.3% of the surveyed households reported that they are unable to pay for meter security while 97.7% percent mentioned that they are in a position to pay.

Table-8.5.9 Willingness to Pay for In-house Wiring

Range of amount	Percent
Nu.1,000	23.62 %
Nu.2,000	18.33 %
Nu,3,000	9.57 %
Nu.4,000	6.15 %
Nu.5,000	8.45 %
Nu.5,001 to Nu.10,000	12.74 %
Nu.10,001 to Nu.20,000	3.48 %
Any amount	16.35 %
Will not be able to afford any	1.31 %

Source: Rural Renewable Energy Development Project BHU-7318 Social Economic Analysis (ADB PPTA Consultants Team, 2010)

(3) Village Technicians

BPC has a customer service office in each of the 19 dzongkhags and it has many customer service centers with BPC engineers and service staff. In order to cover further remote areas, the RE Project will outsource community-based village technicians for their operations and maintenance program. The village technicians will be contracted by BPC to cover both off-grid and remote on-grid areas under the supervision of BPC's customer service centers. The tasks of the technicians in on-grid areas in the rural villages will be billing and collection, monitoring, minor repairs and maintenance.

These village technicians are recruited with recommendation from the village administrative unit and trained on maintenance and minor repair, house wiring, and other customer service activities. After finishing the training program, they are requested to sign a 5-year contract with BPC. Table-8.5.10 shows the training agenda held from October 2009 to January 2010.

The ADB technical assistance program has supported the village technician training wherein 30 village technicians have already been deployed. For over three years, ADB is expected to support comprehensive training programs for 120 village technicians, which include 40% females.

The utilization of village technicians will provide employment opportunities to local people, which would then lead to the increase in their incomes. It will also contribute to women empowerment since the trainees include females.

Table-8.5.10 Village Technician Training Agenda

Date	**Subject**
19.10.2009	Brief introduction
20.10.2009 – 23.10.2009	Basic Electrical signs / symbols
26.10.2009 – 30.10.2009	Usage of tools and instruments, Basic electricity & safety
02.11.2009 – 06.11.2009	House wiring theory
10.11.2009 – 13.11.2009	House wiring practical
16.11.2009 – 20.11.2009	Calculation of load points
23.11.2009 – 27.11.2009	Estimation for house wiring and testing
30.11.2009 – 04.12.2009	Metering and billing
07.12.2009 – 11.12.2009	Lines and substation
14.12.2009 – 18.12.2009	Transformer maintenance
21.12.2009 – 25.12.2009	Maintenance of LV lines
28.12.2009 – 31.12.2009	Revision & clarification
01.01.2010 – 12.01.2010	Solar photo voltaic module
13.01.2010 – 14.01.2010	Final test
15.01.2010	Certification and closing

Source: BPC