ADB

Technical Assistance Consultant's Report

Project Number: 42252
January 2011

Bhutan: Preparing the Rural Renewable Energy Development Project
(Financed by the Japan Special Fund)

Prepared by

PA Consulting Group

Wellington, New Zealand

For Department of Energy (DOE)
Renewable Energy Division, DOE
Bhutan Power Corporation

Asian Development Bank

TA 7318-BHU Preparing the Rural Renewable Energy Development Project

Final Report

Prepared for:

The Asian Development Bank and
Royal Government of Bhutan

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Please note: On 26 July 2010, the PA practice that prepared this report was acquired by Tetra Tech, Inc., and is now part of Tetra Tech, Inc.

FOREWORD

The Asian Development Bank (ADB) engaged PA Consulting Group, New Zealand (PA) in association with Empower Consultants Limited of New Zealand, Hydro Tasmania Consulting of Australia, and IDRG Services of India, to provide technical assistance (TA) to the Ministry of Economic Affairs (MOEA) of the Royal Government of Bhutan (RGOB) for TA No. 7318-BHU: Preparing the Rural Renewable Energy Development Project.

The objectives of this TA are:

- Plan and prepare an investment program to assist the government to achieve its goal of providing electricity for all by 2013
- Develop a sustainable business model for operating and maintaining off- and on-grid rural electrification services
- Develop a wind power pilot project and biogas pilot project.

This TA has four components:

- On-grid rural electrification sourced from hydropower
- Off-grid rural electrification sourced from solar power
- Pilot wind power generation plant connected to the power grid
- Pilot domestic biogas plants.

The executing agency (EA) of this TA is the Department of Energy (DOE) under the Ministry of Economic Affairs (MOEA). The implementing agency (IA) for the on-grid rural electrification component is the Bhutan Power Corporation, Limited (BPC). The DOE is the IA for the off-grid rural electrification component. BPC is also the IA for the pilot wind power generation plant. The IA for the pilot biogas plants includes the Department of Livestock (DOL) under the Ministry of Agriculture and Forests (MOA), and the Bhutan Development Finance Corporation (BDFC), Limited.

This final report summarizes the project's design and implementation plan, and includes all the detailed appendices.

GLOSSARY

CURRENCY EQUIVALENTS
(as of 30 June 2010)

Currency Unit	–	Nu
Nu 1.00	=	$0.022
$1.00	=	Nu 45.0

ABBREVIATIONS

AAAC	–	all-aluminum alloy conductors
ADA	–	Austrian Development Agency
ADB	–	Asian Development Bank
ADF	–	Asian Development Fund
AGM	–	absorbed glass mat (battery)
BDFC	–	Bhutan Development Finance Corporation
BEA	–	Bhutan Electricity Authority
BHU	–	basic health unit
BMNP	–	Blue Mountain National Park (BMNP), and
BPC	–	Bhutan Power Corporation
CGI	–	corrugated galvanized Iron
Chhu	–	river
CO	–	carbon monoxide
CSC	–	customer service center
DGPC	–	Druk Green Power Corporation
DOD	–	depth of discharge (of battery)
DOE	–	Department of Energy
DOF	–	Department of Forestry
DOL	–	Department of Livestock
DSCR	–	debt service coverage ratio
DYT	–	Dzongkhag Yargay Tshogdue (district level government)
Dzongkhag	–	district
EA	–	executing agency
EC	–	environmental clearance
EIA	–	environmental impact assessment
EIRR	–	economic internal rate of return
EMP	–	environmental management plan
ERD	–	Economic Research Division
ESCO	–	energy service company
ESD	–	electricity services division
FIRR	–	financial internal rate of return

FNCA	–	Forest and Nature Conservation Act
FNCR	–	Forest and Nature Conservation Rules
FYP	–	Five-Year Plan
GDP	–	gross domestic product
Gewog	–	administrative block, a group of villages within a district
Gup	–	headman/woman of a block
GYT	–	Gewog Yargay Tshogdue (block administrative government)
HH	–	household
HSS	–	higher secondary school
IA	–	implementing agency
ICB	–	international competitive bidding
IEE	–	initial environmental examination
JDNP	–	Jigme Dorjee National Park
JFFP	–	Japan Fund for Poverty Reduction
JICA	–	Japan International Cooperation Agency
JSWNP	–	Jigme Singye Wangchuk National Park
LED	–	light emitting diode
LPG	–	liquefied petroleum gas
LSS	–	lower secondary school
LV	–	low voltage
MOA	–	Ministry of Agriculture and Forests
MOEA	–	Ministry of Economic Affairs
MOF	–	Ministry of Finance
MOU	–	memorandum of understanding
MSS	–	middle secondary school
MV	–	medium voltage
NCB	–	national competitive bidding
NCD	–	Nature Conservation Division
NEC	–	National Environment Commission
NFE	–	non-formal education
NGO	–	non-governmental organization
NOC	–	no objection certificate
NO_x	–	nitrous oxide
Nu	–	ngultrum (Bhutan's currency)
O&M	–	operation and maintenance
ORC	–	outreach clinic
PA	–	PA Consulting Group
PAM	–	project administration manual
PIU	–	project implementation unit
PM	–	particulate matter
PP	–	pre-primary school
PPE	–	personal protective equipment
PPP	–	public-private partnership
PPTA	–	project preparatory technical assistance

PV	–	photovoltaic
PWLS	–	Phibsoo Wildlife Sanctuary
RE	–	rural electrification
REA	–	rapid environmental assessment
RED	–	Rural Electrification Division, or Renewable Energy Division
REMP	–	rural electrification master plan
RESCON	–	rural energy service concessionaire
RGOB	–	Royal Government of Bhutan
RMNP	–	Royal Manas National Park
RNR	–	renewable natural resources
RRP	–	report and recommendation of the President to the Board
SGIA	–	Second-generation imprest account
SHS	–	solar home system
SNV	–	Stichting Nederlandse Virijwilligers, Netherlands Development Organization
SOE	–	statement of expenditure
SPS	–	safeguard policy statement
TA	–	technical assistance
TSNR	–	Torsa Strict Nature Reserve
$\mu g/m^3$	–	micrograms per cubic meter
UNDP	–	United Nations Development Programme
VEC	–	valued environmental component
WLED	–	white light emitting diode
WACC	–	weighted average cost of capital
WTG	–	wind turbine generator

WEIGHTS AND MEASURES

MW (megawatt)	–	1,000,000 watts
GWh (gigawatt-hour)	–	10^9 Wh
Km	–	kilometer
kV	–	Kilo volt
M	–	meter
kWh (kilowatt-hour)	–	10^3 Wh

NOTE

In this report, "$" refers to US dollars

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1 INTRODUCTION AND SUMMARY

The proposed Rural Renewable Energy Development Project (Project) has four components: 1) on-grid rural electrification (RE), 2) off-grid rural electrification with solar home systems (SHS), 3) a pilot wind power subproject, and 4) a pilot biogas subproject. The project inception mission was carried out in November to December 2009, followed by two missions, one in January to February and another in March 2010. The loan fact finding mission was conducted in May 2010, and the loan appraisal mission in July to August 2010.

1.1 PROJECT RATIONALE

1.1.1 On-Grid Rural Electrification

To alleviate poverty and stimulate economic and social development in rural areas, the Royal Government of Bhutan (RGOB) had started large scale rural electrification projects in the nation's sixth Five-Year Plan (FYP, 1988 to 1993). All subsequent FYPs have included rural electrification as one of their key elements.

In the 2003 to 2005 period, the Japan International Cooperation Agency (JICA) sponsored a comprehensive Rural Electrification Master Plan (REMP) study to identify and assess the households to be electrified in Bhutan. The REMP identified 1,716 villages to be electrified to achieve the goal of electricity for all by 2020. Of these, 1,267 villages (approximately 30,000 households) were identified to be electrified through the expansion of distribution lines, and 449 villages (about 4,000 households) through off-grid electricity, mainly through solar home systems. The REMP study used an economic internal rate of return (EIRR) of 12% as the threshold for on-grid rural electrification. Households were designated for off-grid electricity if the EIRR of an electricity line extension is less than 12%.

The new government, formed in 2008 after the first democratic election in the nation, has given the highest priority to rural development under the tenth Five-Year Plan (2008 to 2013). Thus, the RGOB has accelerated the nation's rural electrification programs and established an ambitious goal of "electricity for all" by 2013.

At the end of 2008, the RGOB had achieved approximately 54% electrification of the nation's households. With the two on-going rural electrification projects (3,576 million yen loan from JICA and $25.3 million grant from ADB), the electrification rate is expected to reach 84% by the end of 2012. That will leave approximately 8,959 households to be electrified to meet the goal of electricity for all by 2013.

To implement the accelerated RE project, BPC has completed surveys for the proposed new electricity distribution lines. During the route surveys, some additional households were identified for on-grid connection, and other households designated for off-grid electrification in the 2005 REMP were included in the on-grid rural electrification due to their proximity to the proposed routes.

In addition, since 2008, the BPC has embarked on a fill-in rural electrification program to extend electricity lines to households in the villages no electrified in previous projects. As a result of this program 8,959 households now remain to be electrified through on-grid extension by 2013. Of this number, the on-grid RE component of the Rural Renewable Energy Development Project will finance 5,075 households; the balance will be financed by the JICA and Government of Austria (in Gasa dzongkhag only).

1.1.2 Off-Grid Rural Electrification

As noted above, the 2005 REMP estimated that close to 4,000 households in remote, isolated off-grid villages will need to be electrified with solar home systems. Since 2008, the DOE has been installing SHS in off-grid villages through various programs financed by the RGOB and ADB. The Project's off-grid rural electrification component is to finance SHS in 1,896 of the 4,000 households. These are the poorest of the poor households in Bhutan. Providing clean, renewable solar energy in off-grid villages will help improve their quality of life.

A sustainable operation and maintenance program is essential to ensure that all the installed SHS sets remain functional in the long run. Various donors and the RGOB have been installing SHS sets in households in off-grid villages since the 1990s. However, due to the lack of standard system design, operation and maintenance (O&M) programs and spare parts, many of the SHS sets installed prior to 2006 are no longer functional. Thus, the Project's off-grid RE component includes a long-term SHS O&M program.

1.1.3 Pilot Wind Power Subproject

Power generation in Bhutan relies almost exclusively on hydropower. The total installed capacity of the country's hydropower plants is 1,488 MW. All of the existing plants are run-of-the-river types whose total generation capacity drops drastically to 288 MW during the winter dry seasons (December through March). If any of the main hydropower plants undergoes downtime for repair, the total firm generation capacity will drop below 200 MW. This low firm capacity cannot meet the system's peak demand during winter dry seasons. The winter power shortages will worsen in the next several years until 2016 when the Punatsangchhu-I hydropower plant (1,200 MW) is expected to come on line. Appendix A: Summary Power Sector Assessment presents more information on the system's power demand and supply.

BPC's system winter peak demand grew by 17% annually between 2005 and 2009, and is expected to reach 300 MW in the winter of 2010, exceeding the system's maximum firm power generation capacity of 288 MW. At present, about 25 MW of existing industrial loads would be curtailed during the winter months, as stipulated in BPC's power supply agreements. If the projected peak demand reaches 300 MW in 2010, further industrial load curtailment would be required in the winter months if power imports cannot be secured from India. Such imports will become increasingly difficult to arrange, especially in the winter months, as India has its own power shortages in the winter. The winter system demand from industrial customers would have to be reduced by 6% annually in the 2010 to 2015 period to avoid any load shedding of the domestic peak demand. As a result of these problems, BPC is not expected to connect any new industrial customers in the next five years. The Department of Industries has declined a number of license applications from industries due to the winter power shortage problems, resulting in adverse impacts on the nation's economic development.

Wind power can supplement the diminishing hydropower in dry seasons to meet the nation's growing power demand, and help enhance its long-term energy security by diversifying generation resources. While wind power has become one of the fastest growing forms of renewable energy in recent years, it has remained unexplored in Bhutan as only limited wind power mapping data are currently available. To supplement the wind data being collected at the country's five meteorological stations, the DOE recently installed wind masts at three additional sites to collect wind data for a more accurate assessment of the wind power potential in Bhutan. The proposed wind power pilot subproject is the initial step to assist Bhutan in harnessing wind power by enabling the DOE and BPC to gain experience in planning, constructing and operating wind farms.

1.1.4 Pilot Biogas Subproject

Bhutan has been consuming about 1.0 to 1.2 million metric tons of fuelwood per year, with about 70% used by households mainly for cooking and heating. Bhutan's fuel consumption of about 1.3 metric tons per capita per year is among the highest in the world. In addition, it has been importing large quantities of fossil fuels for cooking, heating and lighting (5.7 million tons of LPG and 5.2 million liters of kerosene in 2008). Biogas was first introduced in Bhutan in the 1980s as clean and renewable energy for household cooking to help cut down firewood consumption. However, most biogas projects have been abandoned due to lack of spare parts and repair and maintenance services.

To assess the biogas market potential in Bhutan, ADB funded two studies: the Feasibility Study of Biogas in Bhutan and The Market Assessment of Biogas in Bhutan. These studies concluded that at least 16,000 households have the potential to use biogas plants cost-effectively. They also identified major technological, financial, informational, and institutional barriers to biogas development in Bhutan. The development of biogas will help reduce firewood consumption, indoor air pollution, deforestation, and greenhouse gas emissions, and improve the quality of life for beneficiary rural households. The pilot biogas subproject is designed to help Bhutan

build the capacity and overcome market barriers to promote and develop clean, renewable biogas.

1.2 PROJECT DESCRIPTION

The four components of the Project are summarized below.

1.2.1 On-Grid Rural Electrification Component

Since 1995, ADB has financed four consecutive rural electrification projects in Bhutan, including the on-going Rural Electrification (RE4) project.[1] The on-grid RE component will be the ADB's fifth such project in Bhutan (referred as RE5). The RE5 will finance on-grid distribution lines to provide electricity to 5,075 households in six dzongkhags (Lhuntse, Mongar, Samdrupjonkhar, Trashigang, Trashiyangtse, and Zhemgang). It will build upon the success of past projects with an emphasis on incorporating appropriate new cost savings or improved designs such as the use of lighter telescopic poles to reduce transportation costs and less expensive single-phase transformers rather than three-phase transformers. During the technical review of the TA, it was agreed that the RE5 subproject will have the following cost saving or more reliable design features:

Materials/Project Design

Use of telescopic poles in place of tubular steel poles.
Use of polymer insulators.
Use of all aluminum alloy conductors (AAAC).
Transformer mounted on two poles.
Improved UV protection of service cables.
Use of auto reclosure circuit breakers.
Use of preform for stay sets.
Conductor specifications: ACSR Dog and Rabbit.
Use of continuous ground wires in lightning-prone areas.

Civil Works

The transportation and labor costs have been adjusted to reflect the latest conditions of the accelerated rural electrification (RE5) projects. Based on these design features, the RE5 route surveys conducted by the BPC were reviewed and detailed project designs were made.

[1] Grant-0119 BHU: Green Power Development Project, ADF US $25.28 million, 2009 to 2013.

It should be noted that the RE5 will take advantage of the materials savings of the on-going RE4. The RE4 materials savings are a result of decreased materials costs after the global economic slowdown starting in late 2008 and 2009. It is estimated that the materials savings of the RE4 is about $4.888 million. Thus, the RE4 design will continue to be used in certain portions of the RE5, including the 33 kV distribution lines in Zhemgang, and 11 kV distribution lines in Lhuntse, Mongar and Samdrupjonkhar dzongkhags.

Table 1-1 shows the scope of work for the rural electrification projects in six dzongkhags to be financed by ADB. Table 1-2 summarizes the cost estimates and number of households to be electrified.

Table 1-1. Summary Scope of Work (RE5 Net of RE4 Materials Savings)

dzongkhag	No. Households	33 kV Line Construction	110 kV Line Construction	LV Line Construction 50 mm LV ABC	Distribution Substations (No. in Parentheses)
Lhuentse	170	2.75 km telescopic poles	26.36 tubular steel poles	12.75 km telescopic poles	33 kV: (2) 41 kVA 11 kV: (14) 311 kVA
Mongar	1,646	140.93 km telescopic poles	31.01 km tubular steel poles	137.75 km telescopic poles	33 kV: (142) 2,935 kVA 11 kV: (10) 217 kVA
Samdrup Jongkhar	1,062	82.38 km telescopic poles	N/A	76.13 km telescopic poles	33 kV: (63) 1,386 kVA
Trashigang	82	7.61 km telescopic poles	21.85 km tubular steel poles	7.31 km telescopic poles	33 kV: (5) 125 kVA 11 kV: (1) 25 kVA
Trashi Yangtse	389	37.57 km telescopic poles	N/A	34.67 km telescopic poles	33 kV: (30) 833 KVA
Zhemgang	1,726	225.12 km tubular steel poles	N/A	141.51 km tubular steel poles	33 kV: (144) 3,403 KVA
Total	5,075	496.36 km	79.22 km	410.12 km	33 kV: (386) 8,723 KVA 11 kV: (25) 553 kVA

Table 1-2. Cost Estimates for RE5

Dzongkhag	Foreign Materials		Foreign Materials Total	Total Civil Works	Total Project Cost	No. of Households
	RE5	RE4				
Lhuentse	$173,288	$176,044	$349,311	$316,276	$655,607	170
Mongar	$3,705,933	$628,162	$4,334,095	$2,111,765	$6,455,860	1,646
Samdrupjongkhar	$2,926,234		$2,926,234	$1,101,629	$4,027,863	1,062
Trashigang	$248,129	$80,902	$329,031	$263,179	$592,211	82

Table 1-2. Cost Estimates for RE5						
TrashiYangste	$800,301		$800,301	$448,857	$1,249,159	389
Zhemgang	$713,185	$4,022,892	$4,716,077	$2,685,507	$7,401,584	1,762
Total	$8,567,070	$4,888,000	$13,455,070	$6,927,213	$20,382,283	5,075
Note: Includes $4.888 million in materials purchased under ADB RE4 and contingency. Excludes the costs of overhead, administrative, and environmental management plan.						

1.2.2 Off-Grid Rural Electrification Component

This component comprises two subcomponents: 1) installation of SHS for 1,896 households in remote, isolated off-grid villages in ten dzongkhags in 2011 to 2013 to help achieve the goal of electricity for all by 2013, and 2) a sustainable SHS O&M program to ensure all installed SHS will be functional in the long run.

Installation of New SHS

Table 1-3 shows the number of households where SHS will be installed between 2011 and 2013. To minimize the downstream O&M requirements, the specifications of the new SHS to be financed under this Project will be upgraded. For example, a maintenance-free solar battery will be used instead of the lead-acid battery that requires frequent servicing. Long lasting and more efficient light emitting diode (LED) lights will be used instead of compact fluorescent lights (CFL). LED lights will last for 15 years compared to the typical life of 4 years of a CFL, and a 3-watt LED light has an equivalent illumination of an 11-Watt CFL. In addition, a mobile phone charge socket and two LED night lights will be provided. Table 1-4 shows the specifications and unit costs of the new SHS to be financed under the Project. Table 1-5 presents the cost estimates for installing 1,896 SHS sets.

SHS O&M Service Program

Many SHS sets were installed in off-grid villages in the past. However, many of the SHS sets did not function properly due to poor system designs, lack of spare parts, and long-term operation and maintenance services. This subcomponent was designed based on the lessons learned from past projects. These include: 1) the design and specification of SHS should be carefully developed to minimize downstream service requirements, 2) household owners should be trained on the use and simple care of the SHS, 3) long-term O&M services with qualified local technicians are essential, and 4) spare parts and replacement batteries should be made affordable for poor households and available in a timely manner.

This subcomponent will provide sustainable O&M services to the existing and planned SHS to ensure all SHS sets will be functional in the long run. In addition to the 1,896 new SHS sets to be installed in 2011 to 2103, approximately 2,600 SHS sets will be installed by the end of 2010

through various programs. Thus, there will be a total of about 4,500 SHS sets that need to be provided with operation and maintenance services and timely replacement of defective parts.

Table 1-3. New Solar Home Systems to be Installed

No.	dzongkhag	2011	2012	Total
1	Chhuka	563		563
2	Dagana	231		231
3	Gasa		188	188
4	Paro		170	170
5	Haa		44	44
6	Punaka		16	16
7	Samtse	177		177
8	Sarpang	177		177
9	Trongsa		70	70
10	Wangdue		260	260
	Total	1,148	748	1,896

Table 1-4. Specifications and Cost Estimates for Solar Home System

Fixed Capital Cost Parts	Specification	Quantity	Unit Cost (Nu)	Total Cost (Nu)
Solar panel	50 Wp	1	7,875	7,875
Solar panel stand	Painted steel stand	1	675	675
Charge controller	7 Amps	1	990	990
Luminaries	3 Watt WLED	3	1,575	4,725
Night lights	.5 Watt LED	2	270	540
Battery	50 AH sealed dry cell	1	8,100	8,100
M-phone charging socket	Socket & cable	1	450	450
Wires	2.5 sq mm@40 m	1	1,440	1,440
Accessories		1	700	700
Total fixed capital cost				25,495
Total labor costs		1	1,500	1,500
	Total costs			26,995

Table 1-5. Cost Estimates for Installing 1,869 Solar Home System Sets

Item	Nu 1000			US $ 1000		
	Foreign	Local	Total	Foreign	Local	Total
A. Base cost						
Materials	48,339	0	48,339	1,074	0	1,074
Installation	0	2,844	2,844	0	63	63
Implementation	0	928	928	0	21	21
Subtotal	48,339	3,772	52,110	1,074	84	1,158

Table 1-5. Cost Estimates for Installing 1,869 Solar Home System Sets						
B. PIU costs	540	540	1,080	12	12	24
C. Contingency	9,580	845	10,425	213	19	232
Total project investment	58,459	5,157	63,615	1,299	115	1,414

The proposed SHS O&M services will leverage BPC's existing resources and facilities, including over 120 village technicians and over 200 multi-task customer service staff at close to 150 Customer Service Centers (CSC) in 19 dzongkhags. The O&M program was designed to overcome the past difficulty in providing sustainable O&M services to SHS sets located in villages that are difficult to access. In the past, the DOE implemented various O&M programs that used district engineers and/or trained villagers to provide O&M services to SHS sets in remote villages but none of them achieved satisfactory results. The option of using private energy service providers is not practical as there are currently no such providers in Bhutan other than the BPC. The possibilities of fostering new private energy providers are slim as it would be very difficult and expensive to start a new energy service company to serve SHS sets scattered widely among very remote and isolated villages in mountainous areas.

Figure 1-1 illustrates the proposed SHS O&M program, in which,

- BPC's over 120 village technicians, supplemented by over 200 multi-task customer service persons located at close to 150 CSCs in 19 dzongkhags will provide SHS O&M services.
- BPC's maintenance crews from the CSCs will provide technical backup support to village technicians, with BPC' technicians at Electricity Services Division (ESD) offices as the last resort for technical support to SHS O&M
- BPC's additional costs (including labor, training, transportation, spare parts, tools, and other incidental expenses) to provide SHS O&M services will be fully reimbursed by the DOE.

BPC has recruited qualified villagers and trained them as contracted village technicians to provide O&M services to households served with on-grid electricity in villages that are far away from BPC's CSCs. At present, BPC has more than 20 trained village technicians on contract to provide on-grid RE O&M services, and plans to add about 100 more in 2011 to serve new households in remote villages recently connected to the grid. BPC has agreed to have these village technicians take on additional tasks to provide SHS O&M services to households in nearby off-grid villages. It will train these technicians on SHS O&M services and provide them with the necessary tools and instrument. Personnel from BPC's CSCs or ESD offices will provide backup support to village technicians on more complex and difficult repair jobs. In addition, the DOE will procure and deliver SHS spare parts to BPC's CSCs for village technicians to replace parts. Table 1-6 shows the cost estimates for providing SHS O&M services to 4,500 SHS sets in off-grid villages.

Figure 1-1: Proposed SHS O&M Service Program

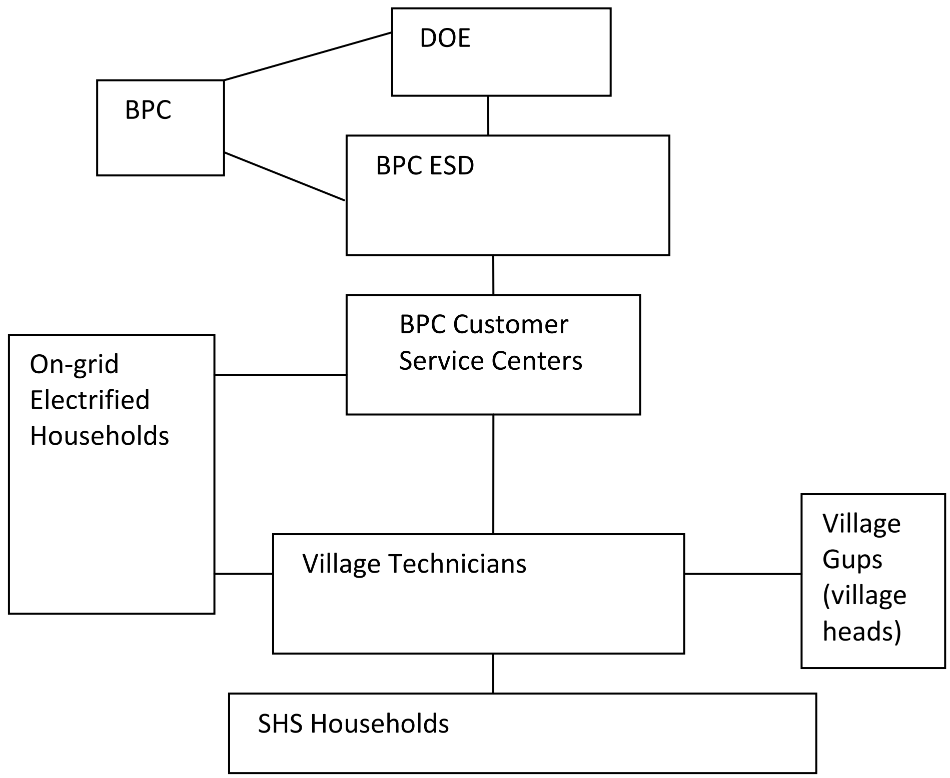

Table 1-6. Cost Estimates (in US$) of Solar Home Systems O&M Services

Item	2011	2012	2013	Total
Spare parts (Government)	157,263	199,577	260,224	617,244
Collection of used batteries	1,603	1,890	2,585	6,097
O&M Services				
Village technicians	138,160	189,970	247,500	575,630
Transportation of used batteries from villages to CS	3,289	3,877	5,303	12,469
Backup support by PBC engineers	55,822	76,756	100,000	232,578
Consulting services	98,120	0	0	98,120
Training*	62,340	19,500	19,500	101,340
Tools*	73,483			73,483
User manuals*	29,000			29,000
Total base cost	619,081	491,750	635,112	1,745,943
Contingency	121,340	96,383	124,482	342,205
Total				2,088,148

* These costs will be financed by JFPR, if approved

1.2.4 Pilot Wind Power Component

The proposed pilot wind power component consists of 1) constructing and operating two 180 kW pilot wind turbines at the Tsimalakha site in Chukha dzongkhag, and 2) installing wind masts at three additional sites.

The component's objectives are to pilot test wind power technology to learn more about the construction and operation of wind farms, and determine the potential for producing wind power to supplement the power supply to alleviate power shortages in the winter peak demand period. The proposed pilot project will support the RGOB's strategy to diversify and enhance long-term energy security, and generate additional power to meet the growing peak demand in the winter.

Table 1-7 shows the key data of the pilot subproject at Tsimalakha.

Table 1-7. Key Elements of Pilot Wind Power Subproject at Tsimalakha Site

Element	Quantity
Wind Turbines and Site	
Unit capacity of the wind turbine	180 kW
Number of wind turbines	2
Total generation capacity	360 kW
Hub height	31 meters
Turbine blade length	10.5 meters
Number of blades per turbine	2
Average wind speed (measured at Tsirang site)	4.8 meters/second
Total land area required	
Permanent uses (foundation)	81 m^2
Temporary uses (during construction)	300 m^2
Wind Mast	
Height	20 meters
Number of wind masts	1
Access road (from roadway to the site)	800 m x 5 m
Connection line to the power grid	163 km

Table 1-8 presents the cost estimates of the pilot wind power subproject.

Table 1-8. Cost Estimates (in US $1000) of the Pilot Wind Subproject

Item	Year			
	2011	2012	2013	Total
A. Investment Costs				
Consultant services	110	60	40	210
Wind turbines, site & electrical works		405	940	1,345
Access road		50	40	90
EMP and social mitigation		25		25
Additional wind monitoring	73			73
Subtotal	183	540	1,020	1,743
B. PIU Costs				
Labor, office, equipment	27	27	27	81
C. Total Base Costs (A + B)	210	567	1,047	1,824
D. Contingencies	38	102	190	329
Total Costs	248	669	1,236	2,153

1.2.5 Pilot Biogas Component

The proposed pilot biogas project will build capacity in the public and private sectors to construct and operate 1,600 biogas plants in rural areas in the period of 2011 to 2014 on a pilot basis. The pilot project is intended to establish the capacity to enable Bhutan to run a large-scale biogas program in the subsequent phase.

The proposed pilot plants will convert cattle dung to biogas to replace the polluting firewood and more expensive kerosene heavily used by households in rural areas where more than 90% of the poor live. The objectives of the proposed biogas pilot project are to 1) improve access to modern household cooking and heating with clean, renewable energy, 2) reduce firewood smoke and greenhouse gases emissions, and 3) reduce deforestation. The byproduct, an odorless bio-slurry, is an excellent organic fertilizer that will increase farmer crop yields. Additional benefits include a reduction in harmful health effects from indoor air pollution resulting from firewood smoke in rural households, especially for women and children, and a positive social impact as the time required for collecting firewood for household needs will be reduced.

To help overcome the financial barriers to developing biogas plants, a substantial subsidy (45% of the total capital costs of a typical biogas plant) and attractive credits will be provided to participating farmers. The DOE will be the executing agency, and the Department of Livestock (DOL) in the Ministry of Agriculture and Forests, and the Bhutan Development Finance Corporation, Limited (BDFC) will be the implementing agencies. A high-level Biogas Advisory Committee consisting of officers from the DOE, DOL, BDFC, SNV Bhutan (a Netherlands Development Organization), and the Ministry of Finance will be established to provide policy direction and oversee the program's implementation. The DOL, with its extensive livestock

extension officers at the district and block levels, will be responsible for marketing, promotion, implementation, monitoring and evaluation.

A Project Implementation Unit (PIU) will be established under the DOL. The SNV Bhutan will provide technical support, training and capacity building to the PIU. The BDFC will serve as the financial intermediary to manage a Biogas Trust Fund to manage and process subsidy funds and credits for participating farmers. Table 1-9 presents the cost estimates of the pilot biogas project.

Table 1-9. Cost Estimates (in US $1000) of the Biogas Pilot Project

Item	Year			Total
	2011	2012	2013	
No. of target biogas plants	100	500	1,000	1,600
A. Investment Costs				
Investment subsidy costs	25	127	255	407
Farmers equity	16	80	161	257
Biogas revolving credit fund	16	80	161	257
Training and information dissemination	8.5	42.5	85	136
Transport for project supervision	10	20	10	40
International expert	161	161	161	484
National expert	31	31	31	93
Administration costs	31	31	30	92
Subtotal	299	573	894	1,766
B. PIU Costs				
Labor (in kind)	50	50	50	150
Office equipment and supplies	8	8	12	28
Subtotal	58	58	62	178
C. Total Base Costs (A + B)	357	631	956	1,944
D. Contingencies	47	84	128	259
Total Costs	404	715	1,084	2,203

1.3 IMPACT AND OUTPUTS

1.3.1 Impact

The impact of the Project will be to sustain inclusive economic growth through widening the access to reliable and affordable clean energy services. As an outcome, the coverage and mix of clean energy supply will be expanded throughout the country in a sustainable manner. Particularly, the Project will contribute to 1) achieving the RGOB's goal of electricity for all by 2013, 2) diversifying energy supply sources to meet a growing demand particularly in the winter dry seasons, and 3) introducing modern cooking to rural households using renewable and clean

biogas to reduce indoor air pollution, deforestation and greenhouse gas emissions. Appendix B presents the design and monitoring framework.

1.3.2 Outputs

The outputs of the Project will include:

- On-grid rural electrification sourced from hydropower (5,075 new households)
- Off-grid rural electrification sourced from solar power (1,896 new installation of solar home systems and 2,500 rehabilitations of existing ones)
- Pilot wind power generation plant (360 kW) connected to grids
- Pilot domestic biogas plants (1,600 new households).

On-grid Rural Electrification

To achieve the RGOB's goal of electricity for all by 2013, there are 8,959 households remaining to be electrified through on-grid distribution line extension. ADB will help electrify 5,075 households in six dzongkhags: Lhuentse, Mongar, Samdrup Jongkhar, Trashigang, Trashiyangtse, and Zhemgang. [2] It is expected that the rest of the households will be covered by parallel financing from JICA and the Austrian Development Agency (ADA). JICA is expected to cover 12 dzongkhags[3] (3,167 households) and ADA is to support Gasa (207 households), where special technology suitable for high altitude areas will be considered. Table 1-10 indicates the number of households by financer.

Table 1-10. Number of Households of On-grid Rural Electrification

Financiers	Households
ADB	5,075
JICA	3,665
ADA	219
Total	**8,959**

[2] It is expected that grant saving of $4.88 million from the ongoing ADB-funded rural electrification project will also be used to purchase part of the materials required.

[3] Including Chukha, Dagana, Haa, Paro, Pema Gatsel, Punakha, Samtse, Sarpang, Thimphu, Trongsa, Tsirang, and Wangdue.

Off-Grid Rural Electrification

To achieve the government's overarching goal of electricity for all, remote pocket areas where grid extension is economically unfeasible will need to be electrified on an off-grid basis. The solar home systems will be distributed and installed for the remaining 1,896 un-electrified households in ten dzongkhags.[4] In parallel with this component, a separate grant regional project is being prepared and expected to be financed from the Japan Fund for Poverty Reduction (JFPR).[5] This regional JFPR project is expected to support comprehensive training programs for 120 village technicians, with provision of the user manuals, consultancy services, tools and equipment required for training and O&M of solar home systems. It will also support the rehabilitation of the existing solar home systems (about 2,500 households), particularly through replacements of solar batteries since the previous programs did not provide replacement of defective batteries.[6] Because the Green Power Development Project has already been covering the electrification of the remaining off-grid public facilities including schools, health clinics, monasteries, and other public facilities, the rest of the coverage will mainly focus on domestic households.

Pilot Wind Power Generation

Expanding rural electrification at a rapid pace will escalate power shortages in the lean season. Alternative energy will help improve national energy security by diversifying generation resources in the long run. Tshimalakha in Chukha dzongkhag has been selected as a pilot project site for wind power generation, based on the site selection criteria.[7] The maximum capacity of the two wind turbines will be 360 kW with a 10-m long blade.[8] The installation of the wind power plant will require the construction of an 800-m access road to mobilize heavy construction machines. To continue to collect wind data in other potential sites, additional wind masts will be installed.[9] This component will enable DOE and BPC to gain experience in planning, constructing, and operating wind farms, and demonstrate the feasibility of generating wind power to help minimize the power shortage problems in winter peak demand periods.

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[4] Including Chukha, Dagana, Haa, Paro, Gasa, Punakha, Samtse, Sarpang, Trongsa, and Wangdue.

[5] The regional grant project, entitled Improving Gender Inclusive Access to Renewable Energy in South Asia, is proposed to serve Bhutan, Nepal, and Sri Lanka. This is tied with the proposed Project and is being processed in parallel for JFPR application. The subsequent livelihood programs and socioeconomic impact assessments are also included in this regional project.

[6] The solar batteries must usually be replaced with new ones every 3 to 5 years.

[7] There are 11 selection criteria: 1) wind resources, 2) topography, 3) available wind turbine sites, 4) land use, 5) land ownership, 6) roads and transport constraints, 7) access road, 8) connection to grid systems, 9) nearest house, 10) geology and foundation conditions, and 11) environmental and social factors.

[8] At least two turbines were designed to maximize the benefits over the fixed costs.

[9] The costs of wind masts are relatively small and further investigation of other sites will be required in parallel to leverage the investment effects of the pilot project.

Pilot Biogas Plants

This component will help diversify energy resources and reduce indoor pollution caused by the use of firewood for cooking by establishing a program through which BDFC will provide credits and subsidies to establish biogas plants for household use. Biogas energy is used mainly for cooking as a complementary energy because electricity is not used much for cooking purpose in rural areas of Bhutan; in these areas, indoor air pollution is affecting health particularly that of women and children. The biogas subproject will be implemented mainly in four dzongkhags,[10] targeting 1,600 domestic households in the 2011 to 2014 period.

Capacity development and training is expected to be supported by SNV (the Netherlands Development Organization). DOE and DOL staff and private masons will be trained and certified for the construction of biogas plants. The capacity building will focus on quality control, project management support, and awareness improvement for the project recipients, including dairy farmers groups and other individual farmers. It will also help create a cadre of privet masons, repair and maintenance services providers, and spare parts dealers to construct and support the long-term success of the biogas sector and to create a commercial biogas market.

1.4 Report Organization

The grant negotiations between ADB and the RGOB were completed in September 2010, and the Report and Recommendation of the President (RRP) for the Project was submitted to the ADB Board of Directors for review. On 29 October 2010, the ADB Board of Directors approved the proposed project, and the grant will be effective in early 2011.

This final report has reflected the review comments received on the draft final report. It documents all the project preparation and analysis tasks completed that were used as the basis for the RRP and associated appendices for the Project. It is organized in a manner similar to that of the RRP. This chapter is the introduction and summary. Chapter 2 summarizes project implementation arrangements. Chapter 3 covers the technical analysis performed, while the financial and economic analyses are summarized in Chapter 4. Chapter 5 summarizes the environmental impact assessment. Chapter 6 covers the poverty and social analysis, and the socio-economic survey conducted. Appendices A through M are the various appendices required by the RRP. Appendix M lists the financial and economic models and other worksheets developed or used in the TA. The original Excel files of these models and worksheets are included in a CD attached to the final report.

[10] Includes Chukha, Samtse, Tsirang, and Sarpang. These dzongkhags are selected as high potential areas for biogas under the market assessment conducted by RETA: Energy for All Initiative. While the assessment concluded there would be potentially 16,000 users in Bhutan, 8 dzongkhags were excluded from the Project's main target to narrow down the pilot project's scope.

2 IMPLEMENTATION ARRANGEMENTS

Appendix C: Project Administration Manual, presents the details of the project implementation arrangements, which are summarized in this chapter of the report.

2.1 INVESTMENT AND FINANCING PLANS

The total Project cost is estimated at $24.91 million, including contingencies. It is considered that ADB will grant $21.59 million, comprising 1) $13.20 million (on-grid rural electrification), 2) $2.41 million (off-grid rural electrification), 3) $1.74 million (wind power generation), 4) $1.28 million (biogas plants), and 5) $2.95 million (overall contingencies). Table 2-1 summarizes the Project's investment and financing plan.

Table 2-1: Investment and Financing Plan ($ million)

		Financing Source		
	Project Cost[a]	**ADB**	**RGOB**	**Other[c]**
A. Base Cost	**(1+2+3)**		**(2)**	**(3)**
On-Grid RE	15.02	13.20	1.82	0
Off-Grid RE	2.73	2.41	0.32	0
Wind Power Pilot	1.82	1.74	0.08	0
Biogas Pilot	1.94	1.28	0.16	0.50
Subtotal [(A)]	21.51	18.64	2.38	0.50
B. Contingencies[b]	3.39	2.95	0.37	(3)
Total (A+B)	24.91	21.59	2.75	0.57

Notes:
[a] In 2010 prices.
[b] Contingencies computed at 15.85% for the total base cost.
[c] Others include (i) biogas users' upfront equity contributions ($0.26 million in total), and (ii) SNV's contribution ($0.24 million) for capacity building support of the biogas program.
Source: Asian Development Bank estimates.

The government will cover the Project's counterpart fund for administration and overhead costs including staffing, transport, any taxes and duties,[11] and part of social and environmental mitigation costs. ADB will finance the off-grid RE's operations and maintenance works including SHS spare parts and costs of village technicians contracted with BPC over the initial three years, subject to management approval. Then, the government will ensure adequate budgetary allocations to cover the costs required for the overall off-grid RE's operations and maintenance

[11] One of the examples is tax deducted at source (TDS).

from the energy royalty revenue account in a preferential manner.[12] Any taxes and duties will be financed entirely by the government.

SNV is expected to co-finance and provide capacity building support for the Project's biogas component. The users of biogas plants will also contribute to their upfront equity for part of plant construction costs.

For the on-grid RE component, the government will relend to BPC the ADF grant through a subsidiary loan agreement with a fixed interest rate to be determined later.[13] Foreign exchange risks will be assumed by the government.[14] For the other two components, the government will make available to 1) BPC the portion of the ADF grant required for the wind power component and 2) to BDFC the portion of the ADF grant required for the biogas component to establish the biogas trust fund to be administered by BDFC. To expedite the grant's effectiveness, the government has been requested to start preparing a subsidiary loan agreement between it and BPC, and a trust fund agreement between it and BDFC.

For the on-grid and off-grid rural electrification components, ADB is coordinating project preparation and implementation with ADA and JICA. For the biogas component, ADB will work with SNV and UNDP, which plans to install 55 biogas plants in 2011.[15]

2.2 IMPLEMENTATION INSTITUTIONAL ARRANGEMENTS

As the executing agency (EA), the DOE will be responsible for overall implementation of the Project. The implementing agencies (IAs) will be the BPC for the on-grid and wind power components, DOE for the off-grid rural electrification, and the Department of Livestock (DOL), Ministry of Agriculture and Forests, and the Bhutan Development Finance Corporation (BDFC) for the biogas component. The EA and IAs for each component are shown in Table 2-2.

Table 2-2: EA and IAs for Each Project Component

Component	EA	IA
On-grid rural electrification	DOE	BPC
Off-grid rural electrification	DOE	DOE (BPC)*
Wind power generation	DOE	BPC
Biogas plants	DOE	DOL and BDFC

12 The three-year base costs for the off-grid RE O&M are estimated at $0.576 million. Any additional costs of BPC staff for backstop support will be reimbursed by the government.

13 The ADF loan will have a repayment period of 32 years, including a grace period of 8 years. The interest charge will be 1.0% during the grace period and 1.5% thereafter.

14 The exchange rate used for the cost estimates is locked at Nu 45.0 against US $1.0.

15 The Mission agreed with UNDP to the close coordination for project implementation under the initiatives of DOE and DOL.

Table 2-2: EA and IAs for Each Project Component

*Under the off-grid RE component, the DOE will own and procure goods, work, and services, and BPC will support operation and maintenance.

2.2.1 On-Grid Rural Electrification Component

The DOE is responsible for planning and overseeing all of the on-grid rural electrification programs to achieve the goal of electricity for all by 2013. BPC will be responsible for the procurement, construction, and operation and maintenance of this component. It has established a Project Implementation Unit (PIU) with a full-time project manager within the Rural Electrification Department who will carry out project planning, implementation and management. The BPC has successfully implemented three past ADB-financed RE projects, and the on-going fourth ADB-financed RE project is being implemented smoothly. It is expected that the implementation of the on-grid RE component will be effective and efficient.

2.2.2 Off-Grid Rural Electrification Component

The DOE, as the EA and IA, will be responsible for procuring, installing, testing and monitoring the 1,896 new SHS sets to be installed in 10 dzongkhags. It has also set up a PIU with a full-time manager for this component. The DOE will implement this component smoothly as it has been successfully installing SHS sets under various programs since 2008. The DOE will outsource O&M services to the existing and new SHS to BPC. BPC will set up a project coordinator under its Distribution and Customer Service Department to coordinate and manage the SHS O&M services. The DOE and BPC will sign an MOU that stipulates their respective roles and responsibilities for the SHS O&M services. All the costs of SHS O&M services, including spare parts, will be the responsibilities of the DOE. To provide close coordination and supervision, a Steering Committee will be established between the DOE and BPC.

2.2.3 Pilot Wind Power Component

As the EA, the DOE will be responsible for planning, monitoring and evaluating the pilot wind power subproject. It has appointed a focal point person responsible for planning, coordinating and overseeing project activities. BPC will establish a PIU within the Distribution and Customer Service Department with a full-time project manager to be responsible for procurement, construction, testing, commissioning, and O&M on the subproject. A project steering committee between the DOE and BPC will be created to oversee project implementation and management. As wind power technology is new to Bhutan, an international wind power expert will be engaged to assist BPC in implementing the subproject, and provide training and capacity building to BPC and DOE personnel.

2.2.4 Pilot Biogas Component

The DOE, as the EA, will be responsible for overall planning and renewable energy policy support for this component. The DOL will be the IA, and the BDFC will be the financial intermediary responsible for processing and managing the biogas trust fund. A Biogas Advisory Committee will be established to oversee project implementation. It will be chaired by the Director General of the DOE; other members will include the Director General from the DOL, MOF, BDFC, and SNV. The DOL will establish a PIU with a full-time project manager and three full-time professional staff who will be responsible for day-to-day project implementation and management. The DOL extension officers at the dzongkhag and block levels will carry out promotion, marketing and quality control activities for the project. SNV will provide capacity building and training to the PIU, the DOL extension officers, and private sector participants including masons, appliance dealers, and service providers. The BDFC will set up a PIU with a full-time project manager to manage the biogas trust fund. The BDFC will process and manage the biogas subsidy and credits according to the criteria and procedures set up by the DOL and agreed by ADB. An MOU among the BDFC, DOE, DOL and SNV will be signed that will spell out their respective roles and responsibilities.

2.3 IMPLEMENTATION PERIOD

The Project will be implemented in the 2011 to 2015 period, with advance procurement of materials, equipment, works and services for the on-grid rural electrification component starting in the fourth quarter of 2010. The Project's other three components will be implemented starting in the first quarter of 2011 in phase to ensure orderly development and progression.

2.4 PROCUREMENT METHODS

For the on-grid rural electrification component, major procurement methods will be international competitive bidding (ICB) for goods, and national competitive bidding (NCB) for civil works according to *ADB's Procurement Guidelines* (2010, as amended from time to time). The RGOB and EA have requested that ADB advance procurement and retroactive financing for the on-grid rural electrification component so the materials and equipment will be available in time for the first dry season of 2011. For the off-grid rural electrification and pilot wind power components, turn-key packages of equipment supplies and installations will be used to simplify the process and administration, and avoid potential quality control problems. For the off-grid SHS O&M services, the DOE will procure bulk quantities of spare parts in time for village technicians to use.

2.5 CONSULTING SERVICES

Both the pilot wind power and biogas components are designed to build the capacity to enable Bhutan to run a larger-scale program in subsequent phases. Thus, individual consultants will be recruited to build capacity, provide training, and assist in program implementation, management, monitoring and/or evaluation. For the wind power component, the individual consultant will be recruited based on data submitted in response to the specific terms of reference for the assignment. For the pilot biogas component, SNV will be engaged for capacity building, training, monitoring and evaluation. For the off-grid SHS O&M component, an individual consultant will be recruited to assist the DOE in spare parts procurement and inventory management, database management, and monitoring and evaluation. All the consultants will be recruited according to *ADB's Guidelines on the Use of Consultants* (2007, as amended from time to time).

2.6 DISBURSEMENT ARRANGEMENTS

The procedures set forth in ADB's *Loan Disbursement Handbook* (2007, as amended from time to time) will be used to disburse the grant based on the arrangements agreed between the RGOB and ADB. For the biogas component, an imprest account and statement of expenditure procedures will be used to provide funds to BDFC.

3 TECHNICAL ANALYSIS

3.1 ON-GRID RURAL ELECTRIFICATION

The proposed RE5 is the last phase of Bhutan's national rural electrification efforts to provide electrification for all. The target households are located in more remote and isolated areas, making transportation and the erection of equipment and materials increasingly expensive and technically difficult. Thus, cost-saving designs will be incorporated into the RE5, including lighter weight telescopic poles in lieu of heavier tubular steel poles, lighter and less costly single-phase transformers instead of three-phase transformers, better ultraviolet protection service cables, and others. Appendix D: On-Grid Rural Electrification Technical Report, presents the on-grid rural electrification project design and bills of quantities for the procurement packages. To achieve the least-cost rural electrification, if the economic internal rate of return (EIRR) for the rural electrification through on-grid electricity distribution extension is less than 12%, then the alternative off-grid solar home systems will be used.

3.2 OFF-GRID RURAL ELECTRIFICATION

Similar to the on-grid rural electrification, the system design of the SHS must also consider the difficulty and cost of transporting, installing and maintaining SHS sets in more remote households in off-grid villages. Thus, lighter weight and maintenance-free solar batteries, more efficient and longer life LED lights, and more reliable controllers were selected to reduce the transportation costs and needs for downstream repair and maintenance. The analyses and selections of the SHS specifications are summarized below.

3.2.1 Design of Solar Home Systems

White light-emitting diode (WLED) light bulbs were selected to replace the compact fluorescent light (CFL) used in previous SHS programs. A 3-watt WLED light bulb can replace an 11-watt CFL light bulb. Compared to CFL light bulbs, the advantages of WLED light bulbs include: 1) longer lives (50,000 hours for WLED light bulbs compared to 8,000 hours for CFLs), 2) more efficient (a 3-watt WLED light bulb has more lumens than an 11-watt CFL light bulb), and 3) reduced power demand (3 watts versus 11 watts) resulting in cost savings from downsized solar panel, controller and battery. Table 3-1 shows a life-cycle cost comparison between WLED and CFL light bulbs. As shown, the life-cycle cost of WLED light bulbs are $66 compared to $169 of CFL

light bulb. A 3 x 3-watt WLED lighting set has 450 lumens, much higher than the 363 lumens of a 3 x 11-watt CFL lighting set. A 3-watt WLED light bulb is much more cost-effective than an 11-watt CFL light bulb. This analysis does not even consider the other benefits of WLED light bulbs such as cost savings of the reduced sizes of solar panel, controller and battery, and cost savings from the less frequent part replacements.

Table 3-1: Life Cycle Cost Analysis of WLED vs. CFL Light Bulbs

Life Cycle Cost Comparison	CFL	LED Light
Light bulb life (hours)	8,000	50,000
No. of light bulbs/life cycle	18.75	3
Cost/light bulb	$9	$22
Total life cycle cost	$169	$66
Luminance Comparison		
Watts per light bulb	11	3
Lumens/Watt	33	150
Total lumens/light bulb	363	450

With the WLED light bulbs, the SHS sets to be installed will have the following optimized specifications:

1. A 50 Wp PV panel, either mono or polycrystalline, made to full international standards and certifications.

2. A minimum 7 amp charge controller, suitable for use with the battery type selected and with all reverse polarity and battery protection modes incorporated.

3. A deep cycle lead acid battery of absorbed glass mat (AGM) maintenance-free design, of not less than 50 AH @C10. The battery shall have the date of manufacture clearly marked. Terminals are to be bolt-through type and not circular automotive posts.

4. Three 3-Watt WLED lighting fixtures to supply not less than 150 lumens per Watt. WLED fittings must fit standard available lighting fixtures and be reverse polarity protected.

5. Two 0.5-Watt LED night lights and a mobile phone charge socket.

This SHS set will provide an average of 4 to 5 hours of power per day for SHS households. The detailed technical specifications of the key components are summarized in the flowing sections.

3.2.2 Solar Panel Specifications

- Either mono-crystalline or polycrystalline panel technologies are acceptable.
- The solar panels shall meet the requirements set in IEC 61215:2005.
- Each module must be labeled indicating at a minimum: manufacturer, model number, serial number, peak Watt rating, voltage and current at peak power, open-circuit voltage and short-circuit current.
- Solar panels shall have framed module with type A junction box (rain tight) accepting PG 13.5 conduit/cable fitting.
- Panels have to be packaged for safe transportation and prepared for rough handling and transport to remote rural areas.
- The solar panel shall have a certificate of compliance, issued by one of the major international recognized testing laboratories.
- Performance warranty cover at least 20 years of operation.

3.2.3 Controller Specifications

- The regulator or charge controller must protect the battery against overcharge and excessive discharge, besides giving information to users on the general state of the system.
- The charge controller must ensure safe and reliable operation in a range of ambient temperatures from -5° C to + 40° C.
- The “load voltage disconnect” must respect the established limits for the maximum depth of discharge (DoD_{max}) of the battery (70%). Regardless of this condition, it should never be lower than 11.5 V.
- Load disconnection must take no longer than 30 seconds as from the moment on which the disconnection voltage is achieved.
- The “load voltage reconnect” must be between 0.9 and 1.2 V higher than the disconnection voltage.

- The disconnection, reconnection and alarm voltages must have a precision of at not less than ± 0.5% (± 60 mV), and must remain constant through the full range of possible operation temperatures.

- The "final charge voltage" (high-voltage disconnect) must be 14.4 V for a tubular battery. These values are to be interpreted at 25° C. The thresholds must be compensated in temperature, at the rate of between -18 to -24 mV/°C.

- The final load and replacement voltages must have a precision of at least ± 0.5% (± 60 mV).

- In the case of ON-OFF regulators, the "replacement voltage" must be between 13 V to 13.5 V. These values are to be interpreted at 25º C.

- The charge controller shall not use electromechanical relays.

- The charge controller shall use a pulse with modulation strategy to control the charging current.

- The maximum parasitic current draw of the controller, when no LEDs are lit, should not exceed 5 mA.

- The regulator must allow for the photovoltaic generator to effectively charge the battery for any voltage higher than 9 V.

- The connection terminal must easily admit cables with a section of minimum 6 mm^2.

- The charge controller boxes must offer a protection of at least IP 22.

- The regulator must be protected from reverse polarity connection errors on both the battery and the PV inputs.

- The charge controller must prevent reverse current flow into the PV module at all times.

- The regulator must resist, without any damages, any possible condition related to the operation of the battery. In addition, it must be able to accept without any damage the maximum open circuit voltage of the PV panel, and be not less than 26 V.

- The regulator must protect the loads against damage related to operation without a battery.

- The regulator must be protected from excessive voltages induced by atmospheric discharges (static) through transitory suppression devices.

- The acoustic noise coming from the regulator must be lower than 35 DBA, as measured at a distance of one meter.

- The regulator should not produce any interference, either radiated or conducted, in the radio frequencies: AM 530 kHz – 1600 kHz; SW1: 2.3 MHz – 7 MHz; SW2: 7 MHz – 22 MHz, and in any operating condition.

- The regulator must include, as a minimum, the following operating indicators:

  Charging mode
  State of battery: charged, half full and empty
  Alarms: short circuit, excessive current, excessive voltage and load disconnect.

- The model number, serial number, rated voltages and currents should be noted on the charge controller case.

- The load regulator must have a certificate of compliance, issued by any of the major international laboratories, with one of the following standards: 1) Recommended Specifications PVRS 6/6A of the Photovoltaic Global Approval Program-PVGAP, and 2) Universal Technical Standard for Solar Home Systems - Thermie B: SUP 995-96, ECDGXVII, 1998. Version 2, revised 2001.

- A warranty of not less than 2 years of operation shall be provided.

3.2.4 Battery Specifications

- The battery should be a vented-type “heavy duty” tubular lead acid battery of nominal value 12 V.

- The battery may be an AGM maintenance-free design.

- The nominal battery capacity shall be 50 AH @C10.

- The battery shall meet the requirements and recommendations given in IEC 61427: 2005.

- The battery must ensure safe and reliable operation in the whole range of ambient temperatures from -5° C to + 40° C.

- Technical specifications of the battery, including the nominal 50 AH capacity at a certain current (e.g. I_{10}, $I_{20,}$ I_{100}), the number of cycles at different dept of discharge and maximum depth of discharge shall be clearly indicated.

- Cycle life of the battery (i.e., before its residual life drops below 80% of the rated Ah capacity), at I_{10} must exceed 1500 cycles when discharged down to an average depth of discharge (DOD) of 50% at the discharge rate of 10 hours.

- The maximum permissible self-discharge rate is 5% of rated capacity per month at 25° C.

- The battery shall have a flat, bolt on-type post terminal to allow firm and effective electrical connections. Round, automotive type terminal posts are not acceptable.

- The battery shall have a certificate of compliances, issued by any of the major international testing laboratories.

- Batteries should be packaged in order to withstand transportation to remote areas.

- The manufacturing warranty must be not less than 2 years.

3.2.5 LED Lamp Specifications

- LED lamps shall have a nominal input voltage of 12 V.

- The LED unit must ensure safe and reliable operation in the whole voltage range of -10% to + 25% of the nominal voltage (10.8 V to 15 V), and in the whole range of temperatures from -5° C to +40° C.

- The power consumption shall range from 1.4 to 3.6 W.

- The LED lamps must deliver at minimum a luminous efficacy of at least 150 lumens / W (at 25° C ambient temperature).

- The LED lamp must be fully protected against reverse polarity.

- The lamp must be fully compatible with standard lamp holders.

- The emitted light shall be cool or warm white.

- The wide angle shall be between 120° to 125°.

- Lamps should be marked with the manufacturer model number, rated voltage, wattage and date of manufacture or batch number.

- The manufacturer's warranty shall cover at least 3 years.

3.3 SHS OPERATION AND MAINTENANCE BUSINESS MODEL

In 1990s and early 2000s, solar home systems were installed for households in off-grid villages through various donor organizations and government agencies. However, many of the installed SHS sets are no longer functional or had been abandoned due to unreliable equipment and lack of repair and maintenance services and spare parts. The key lessons learned from past projects include 1) there should be a long-term operation and maintenance program for the installed SHS sets, 2) timely and affordable spare parts should be available to the beneficiary households, 3) SHS should be designed to minimize the needs for O&M services, and 4) users should be trained to perform simple maintenance and on the proper use of the SHS sets.

As noted in the previous section, the specifications of the new SHS sets to be installed under the Project have been improved to minimize the needs for downstream O&M. The following sections summarize the development of a sustainable SHS O&M business model.

3.3.1 Past SHS O&M Approaches

SHS sets are typically installed for households in off-grid villages that are far away from farm roads in mountainous areas, and have a low household density. Thus, it would be very challenging to establish a sustainable SHS O&M service program.

Various O&M approaches have been taken by the DOE in the past to operate and maintain the SHS sets installed in off-grid villages, but no satisfactory results have achieved so far. The past and ongoing SHS operation and management practices are summarized below:

Use of District Technicians

The DOE has provided training to the district technicians to provide O&M services to the SHS sets in off-grid villages. However, the trained district technicians could not attend effectively to SHS system repair and maintenance in remote villages. This was because the district technicians are district government employees. They have other development duties to perform, and it was not easy for them to allocate time to SHS system maintenance in remote villages. In addition, there were not adequate resources to cover their travel expenses to remote villages.

Use of Village Women Technicians

Under ADB TA 9093-BHU: Rural Electrification Training Program[16], 35 rural women technicians in 13 dzongkhags were trained for 6 months in India as village solar technicians. They had installed about 500 SHS sets in 48 villages and were to provide O&M services to the installed SHS sets. However, this program was not effective either. It was observed that some solar technicians could not live up to the expectations to provide the needed repairs of broken SHS sets. In addition, SHS users failed to pay the agreed monthly fees as the users felt solar technicians are not required as there are typically no problems for new SHS sets in the first or two years.

Use of DOE Renewable Energy Division's (RED) Technicians

Recently, the RED has dispatched its technicians, as the last resort, to repair broken SHS sets in off-grid villages. This cannot be sustained as it is too costly to provide operation and maintenance services from a centralized location and the number of SHL sets increases rapidly. Furthermore, it is not appropriate for the DOE, as a policy and planning body, to establish a SHS system operation and maintenance unit in the Department.

3.3.2 Past Studies on SHS O&M Models

In the past few years, a few studies have been carried out to develop business models for operating and maintaining SHS sets in remote off-grid villages. The O&M business models recommended by these studies are summarized below.

Village Technician / District Engineer Model

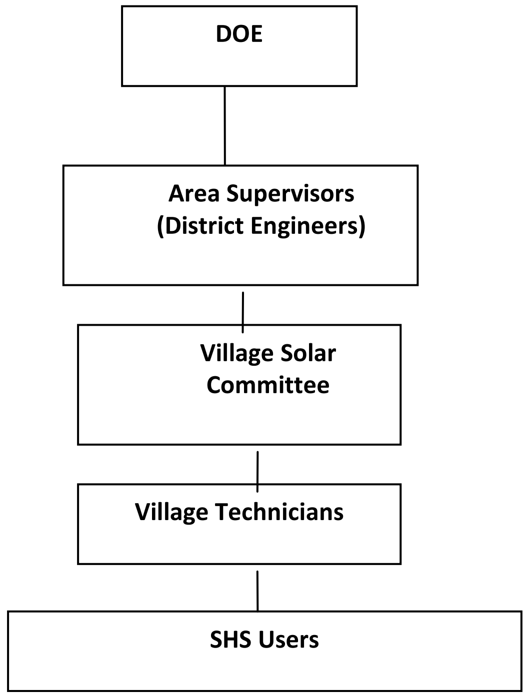
The following simplified diagram shows the SHS O&M model recommended in the draft final report of ADB TA 4776-BHU: Accelerated Rural Electrification.[17]

This business model relies on village technicians to install, maintain and repair SHS sets in villages. The village technicians will be selected by the village solar committee for training. The village technicians will be supervised by the dzongkhag (district) engineers who serve as the area supervisors. The district engineers will:

- Provide technical support to village technicians
- Assist in training village technicians
- Interact with village committees and local governments
- Manage spare parts inventories and distribute them to villages
- Visit each village to check SHS sets at least once a year

[16] ADB 2006, Technical Assistance to the Kingdom of Bhutan for Rural Technicians Training Program, Manila.
[17] ADB, 2006, Technical Assistance to the Kingdom of Bhutan for Accelerated Rural Electrification, Manila.

Figure 3-1: Village Technician / District Engineer O&M Business Model Recommended in TA 4776

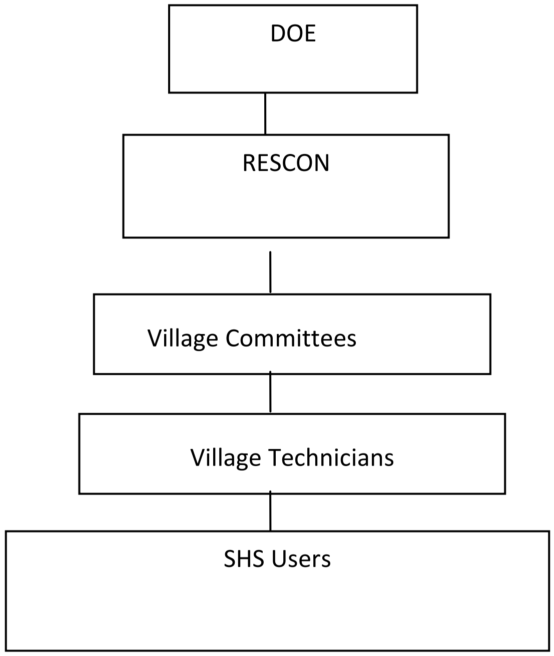


Because pilot testing of this recommended O&M model was not carried out, the feasibility of the concept in Bhutan was not established. Some of the concerns of this model are that district engineers are local government employees with their own regular duties to be carried out. The recommended SHS system O&M tasks in remote villages are extra duties for which no clear funding and mandates are provided. Under this circumstance, district engineers could not be expected to undertake the recommended SHS system O&M tasks effectively. Also, the proposed model did not address the important issue of preventing trained village technicians from leaving their villages. No detailed operation, maintenance and spare parts management procedures were established in the report either.

Concessionaire Model

Another SHS O&M business model was recommended in the UNDP/DOE report entitled "National Renewable Policy and Program for Sustainable Development Project, Mini-Micro Hydels and Solar PV Systems for Sustainable Development in Off-Grid Rural Areas of Bhutan, November 2006." Figure 3-2 is simplified diagram of the recommended model.

Figure 3-2: Concessionaire O&M Model Recommended in the UNDP Report



This model would involve regional energy services concessionaires (RESCON) to be responsible for overall SHS project planning, design, installation, and O&M. Specifically, the RESCON would:

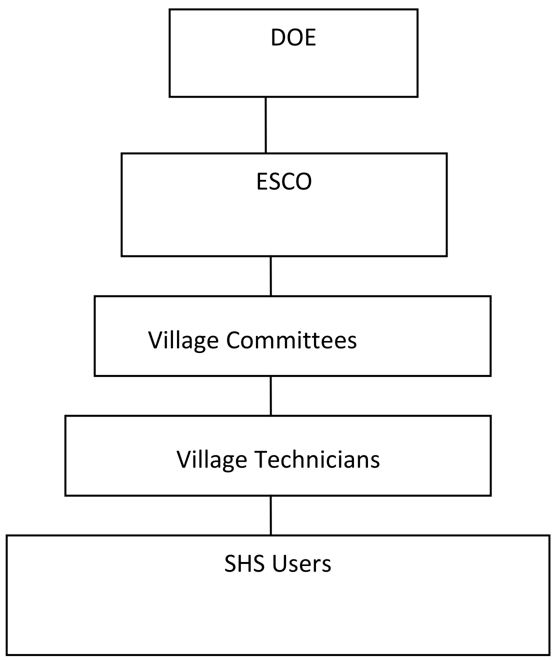
- Design SHS specifications
- Work with village committees to recruit and train village technicians to install, maintain and repair SHS systems
- Manage spare parts inventory
- Dispose replaced solar batteries
- Interact with local governments
- Monitor and report on a regular basis.

The model recommended that the DOE use a public bidding process to select RESCONs. However, there is a lack of rural energy services providers in Bhutan that are qualified to be a RESCON. The model recognized this shortcoming and suggested that the DOE provide capacity building and training to private entities so they could be potentially qualified as a RESCON. But the model did not spell out the details on how to build the capacity and provide training for such a new industry. Neither were details provided on how the proposed model would be funded. Due to the above mentioned issues, this recommended model was not tested in Bhutan.

Energy Service Company Model

The UNDP study also reviewed another SHS O&M model that uses private energy service companies (ESCO) to provide SHS operation and maintenance services. The ESCO model, with different variations, has been successfully used in a number of developing countries including Lao People's Democratic Republic, Sri Lanka, and India. Figure 3-3 is a simplified diagram showing the arrangement of the ESCO O&M model.

Figure 3-3: ESCO O&M Model



In this model, the DOE would select a private ESCO through competitive bidding process to provide SHS system O&M services in a dzongkhag or a region. The ESCOs would work with village committees to select village technicians for training on SHS system O&M services. ESCOs would also be responsible for spare parts inventory management and disposal of replaced batteries. They would collect monthly service fees from SHS users that are to be negotiated and pre-approved by the DOE.

PA has reviewed this ESCO O&M model with DOE and provided detailed information on an example model using ESCOs in each province for SHS system O&M that has been successfully implemented in Lao PDR. However, DOE felt that this model would not be practical in Bhutan either. There are currently no private ESCOs in Bhutan. Furthermore, potential energy service providers may not be interested in this business opportunity due to the high costs associated with the low density and wide spread of SHS users in the remote isolated villages, and the low affordability of the households in remote villages.

3.3.3 The Proposed SHS O&M Business Model

The proposed SHS O&M business model will leverage the existing resources and institutional strength of the BPC to provide SHS O&M services in off-grid villages in addition to its own on-grid O&M services for households.

To provide O&M services to its customers, BPC has established offices called Electricity Service Divisions (ESD) in all 19 dzongkhags except Gasa, which is currently under the jurisdiction of the ESD Punakha. Each ESD is staffed with engineers and service personnel to provide O&M services to customers. In addition to the ESD offices, each ESD has several Customer Service Centers (CSC) in each dzongkhag to provide services to customers remote from the ESD office. Each CSC is staffed with a few multi-task customer service employees providing on-grid O&M services including metering, billing and collection. At the end of 2009, BPC had close to 150 CSCs throughout the country with over 200 multi-task customer service staffs to serve a total of about 43,710 rural household customers (accounts) and 25,530 urban household customers.

In 2009 to cut costs, BPC started recruiting and training village technicians to provide O&M, metering, billing and collection services to on-grid customers in villages far from the CSCs. These village technicians serve as contracted technicians and agree to stay in their own villages for at least five years to provide O&M services. In the first quarter of 2010, BPC had over 20 village technicians; it plans to recruit and train over 100 additional technicians in 2011 to serve new on-grid households. In the proposed SHS O&M model, the DOE will sign an agreement with BPC requesting BPC's village technicians to provide SHS O&M services in nearby off-grid villages. The DOE will provide training to village technicians on SHS O&M services and the necessary tools and instruments. BPC CSC multi-task customer service personnel or ESD engineers will provide backup support to village technicians for more complex and difficult repair tasks. The key features of the proposed SHS O&M model include:

- Use BPC's close to 120 contracted village technicians, supplemented by nearly 200 multi-task customer service persons located at around 150 Customer Service Centers in rural areas to maintain and repair SHS sets.

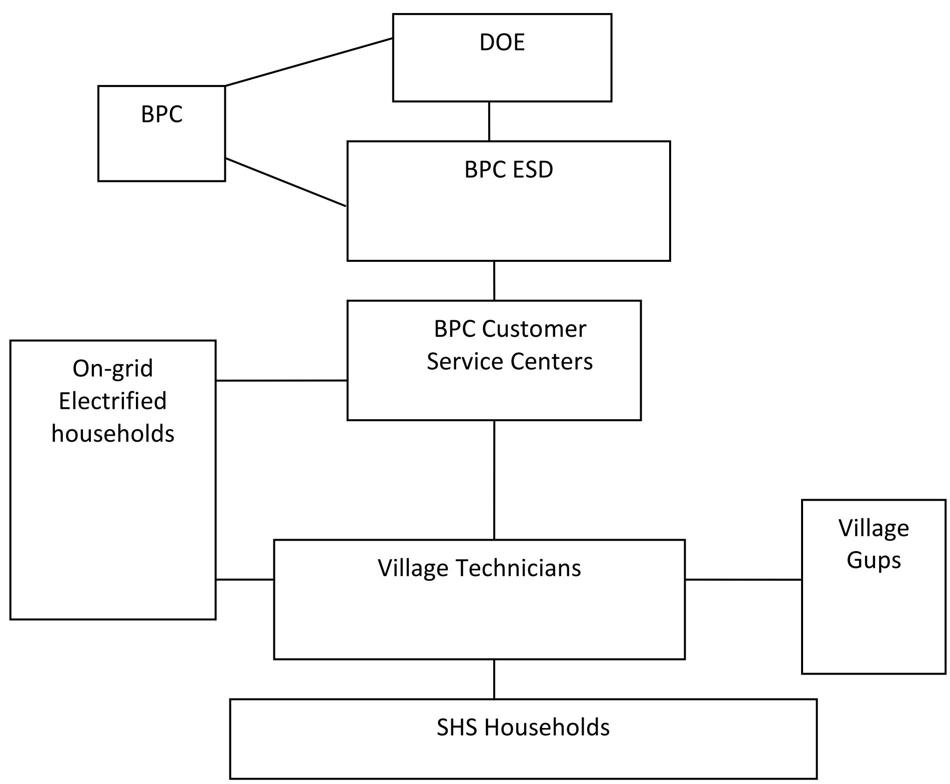
- BPC's existing maintenance crews at the CSCs will provide technical backup support to village technicians, with BPC' technicians at ESD offices as the last resort technical support to SHS O&M services.

- DOE will provide necessary training, tools and instruments as well as spare parts so village technicians can carry out SHS O&M services effectively.

- BPC's additional costs (including labor, training, transportation, spare parts, tools, and other incidental expenses) of providing SHS O&M services will be fully reimbursed by the DOE.

Figure 3-4 shows the proposed SHS O&M model integrated with BPC's on-grid O&M services. Compared to the recommendations of the previous studies, the proposed integrated SHS and on-grid O&M service model does not require developing new energy service companies or creating new energy service concessionaires. Thus, the proposed model can be implemented in a timely manner to ensure all the installed SHS sets will work properly by 2013. The proposed model will integrate O&M services of on- and off-grid rural electrification, therefore, improving the productivity and efficiency of the overall rural electrification O&M services. Appendix E is a draft Memorandum of Understand (MOU) between the DOE and BPC spelling out the respective responsibilities and roles for the SHS O&M services.

Figure 3-4: Proposed Integrated SHS and On-Grid O&M Service Business Model



3.4 PILOT WIND POWER PROJECT

The Tsimalakha site was selected as the proposed pilot for the wind power project based on wind power site criteria, including wind resource, land use and ownership, distance to the nearest distribution power lines, nearby settlements and roadways, transportation accessibility, suitability of terrain, not in environmental or social sensitive areas, and others. The Tsimalakha site was ranked highest of the more than a dozen sites investigated. Its key features include:

- Land belongs to BPC. BPC currently does not have plan for the site, so the land can be transferred to the proposed project.

- The site is an open area without tree cover.

- It is not in an environmentally sensitive area or bird migration path.

- Access to the nearest distribution substation is though a step-up transformer at the wind site connecting to one of the existing 11 kV lines that runs through either the eastern or western part of the site.

- The site is conveniently located for operation and maintenance personnel.

- The distance to the existing road requires about 0.8 km of access road and tracks.

- The current design and condition of the road from Phuntsholing to Chukha make the transportation of wind turbine blades longer than 10 meters (about 150 to 200 kW installed capacity) difficult.

- The possibility of transporting longer blades by road using specialized transport has been ruled out due to the lack of available equipment. Road widening and other options at tight radius bends in the road have been ruled out due the high cost, as has transporting the blades using a helicopter.

- There are restrictions to the available area of the site imposed by the need to:

    - keep within the boundaries of the BPC land
    - ensure adequate safe clearance from the 220 kV transmission line tower and conductors that run through the west of the site
    - keep away from the steep topography to the north and south of the site and the river valley wall to the east
    - maintain sufficient distance between the proposed wind turbines and the existing settlements to keep the ambient noise to acceptable levels.

- Based on these land restrictions, the available land area for development at Tsimalakha limits the number of wind turbines that can be installed to two wind turbines of 180 kW each.

3.4.1 Project Design

The project consists of three main components:

- Wind turbine generators (WTG)
- 163 meter connection line to 11 kV distribution line
- 800-meter long 5-meter wide access road from the nearest roadway to the wind turbine site.

There will be two wind turbines, each with a capacity of 180 KW. The rotor blades are 22 meters in diameter with a 31-meter tower height. Each turbine has two blades that are 10.5 meters in length. The cut-in and cut-out wind speeds are 4 meters per second and 25 meters per second, respectively. The rated wind velocity is 12 meters per second. The wind power site will have:

- Two wind turbine generators
- foundations, hardstand and laydown areas, roads, fences and other associated infrastructure
- underground cables connecting WTGs to the electrical substation via fused switch panel enclosures (up to 6 m x 4 m x 2 m high) WTGs
- communications between the WTGs and the switchyard
- a permanent 20 m, guyed, wind monitoring towers at the site
- connection to the existing 11 kV distribution line.

3.4.2 Wind Resource Analysis

The estimated energy generation from the proposed wind power plant at Tsimalakha is derived from wind data acquired at a 20 meter monitoring mast installed at Damphu in the Tsirang dzongkhag by the Department of Energy. In mid-April 2010, the DOE installed a 20-meter wind mast at the Tsimalakha site that has starting collecting actual wind data. The additional wind data collected at the site for at least 12 months will be analyzed to help refine the wind turbine design and specifications before the actual project implementation.

Figure 3-5 displays average monthly wind speed variations at a 20 meter height at Damphu that is likely to apply at Tsimalakha. There is a minor peak in average wind speed in the month of April, and lower wind speeds in late autumn-winter. However, the variation in average wind speed from one month to the next is relatively low, suggesting some energy generation throughout the year.

Figure 3-6 shows the wind speed variation through a 24-hour period, for each month of the year. The diurnal variation in wind speed is strong, with low wind speeds overnight, and the highest wind speeds during the early afternoon. These profiles suggest the wind turbine will rarely operate overnight, and will only briefly attain rated output during each day.

Figure 3-5: Monthly Average Wind Speed at Damphu

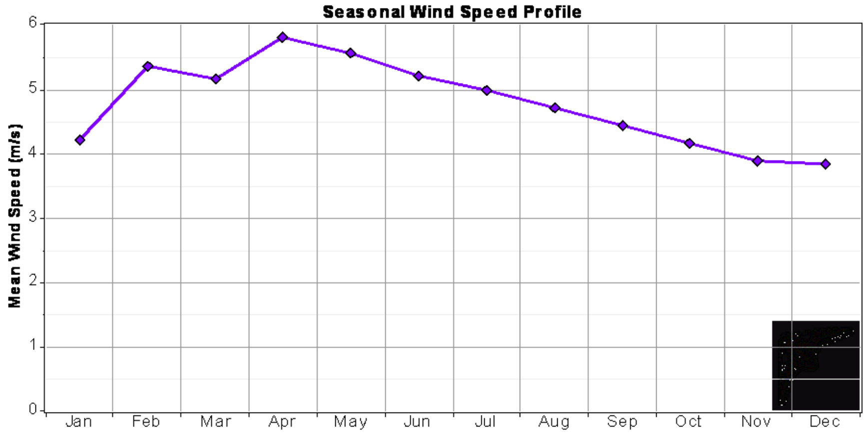


Figure 3-6: Diurnal Wind Speed Profiles at Damphu

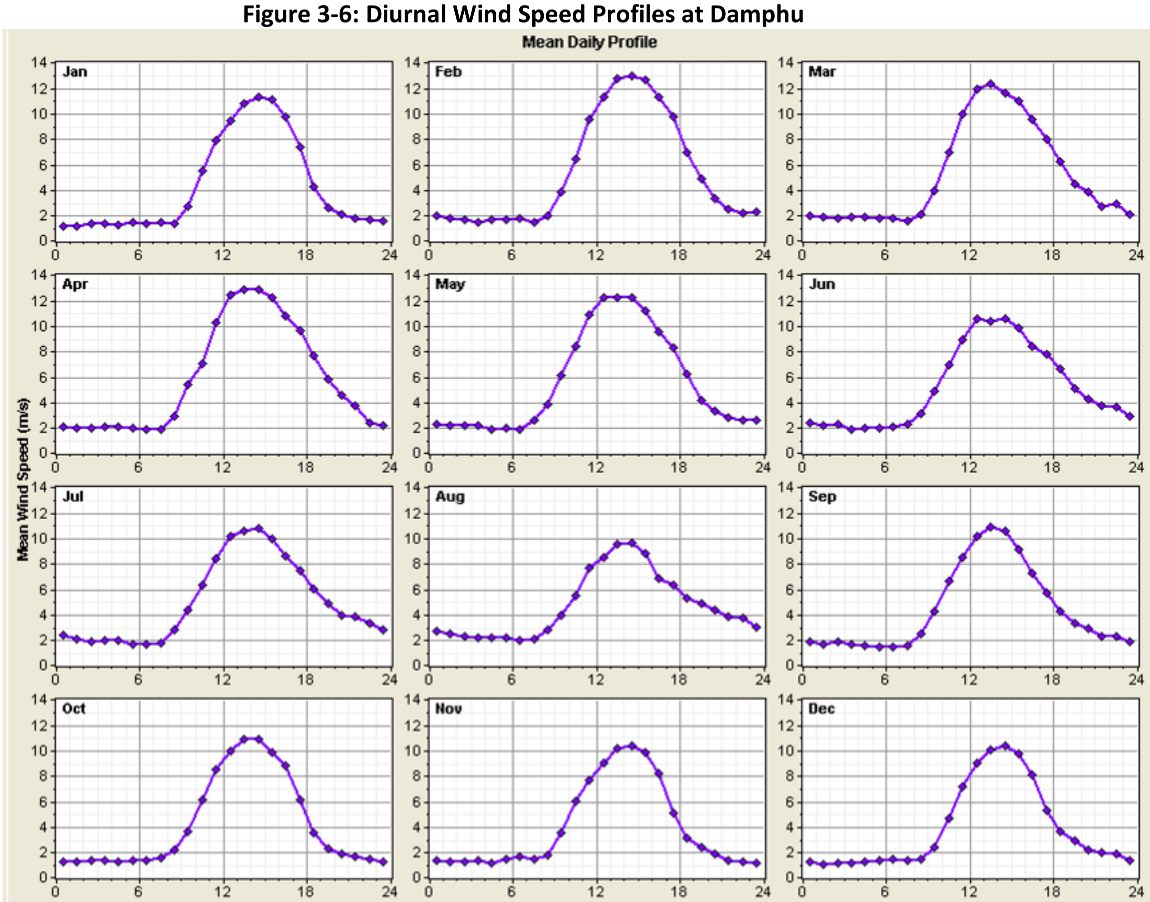
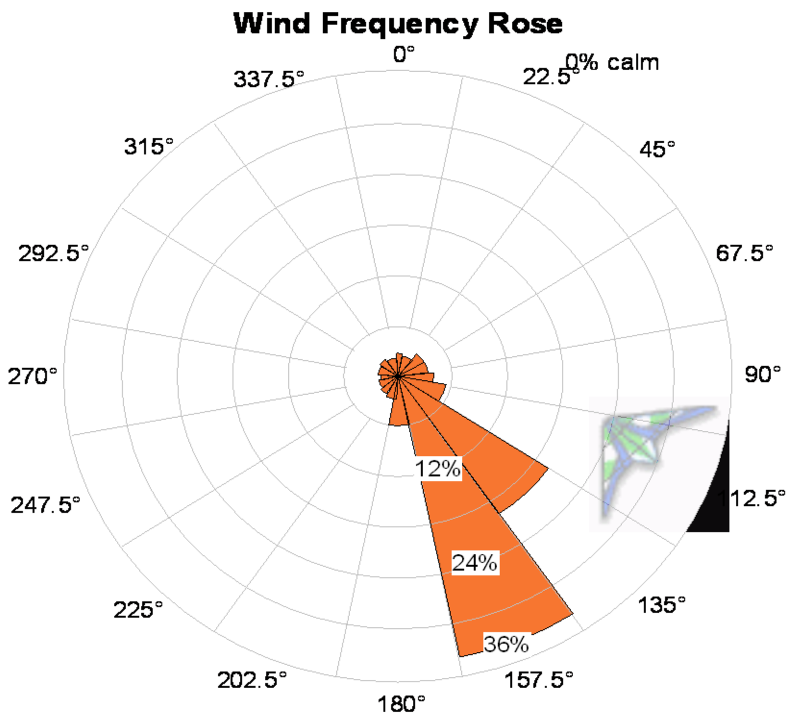


Figure 3-7 presents the wind direction rose and energy rose at Damphu. These plots indicate a highly directional wind flow. It is expected that Tsimalakha will have a similar highly directional wind flow from the south. Figure 3-8 displays the wind speed distribution at Damphu. A typical wind speed distribution is often assumed to follow a Weibull distribution.

Figure 3-7: Wind Direction Frequency Rose and Energy Rose at Damphu



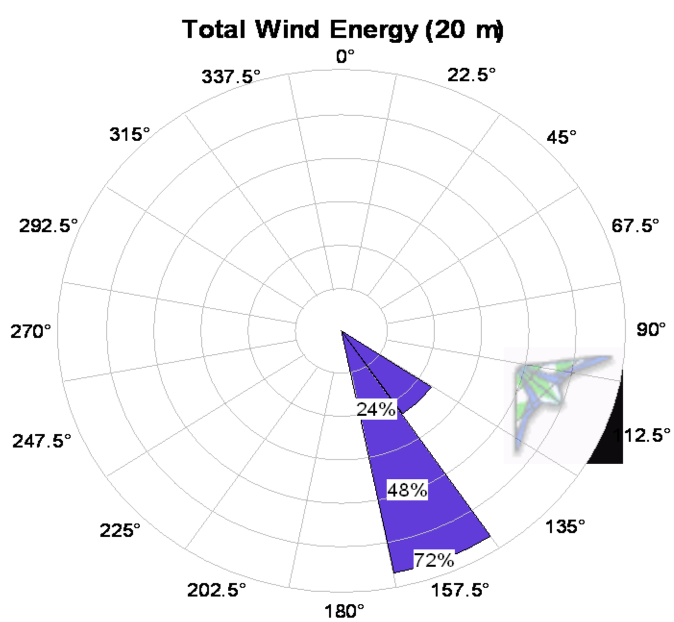
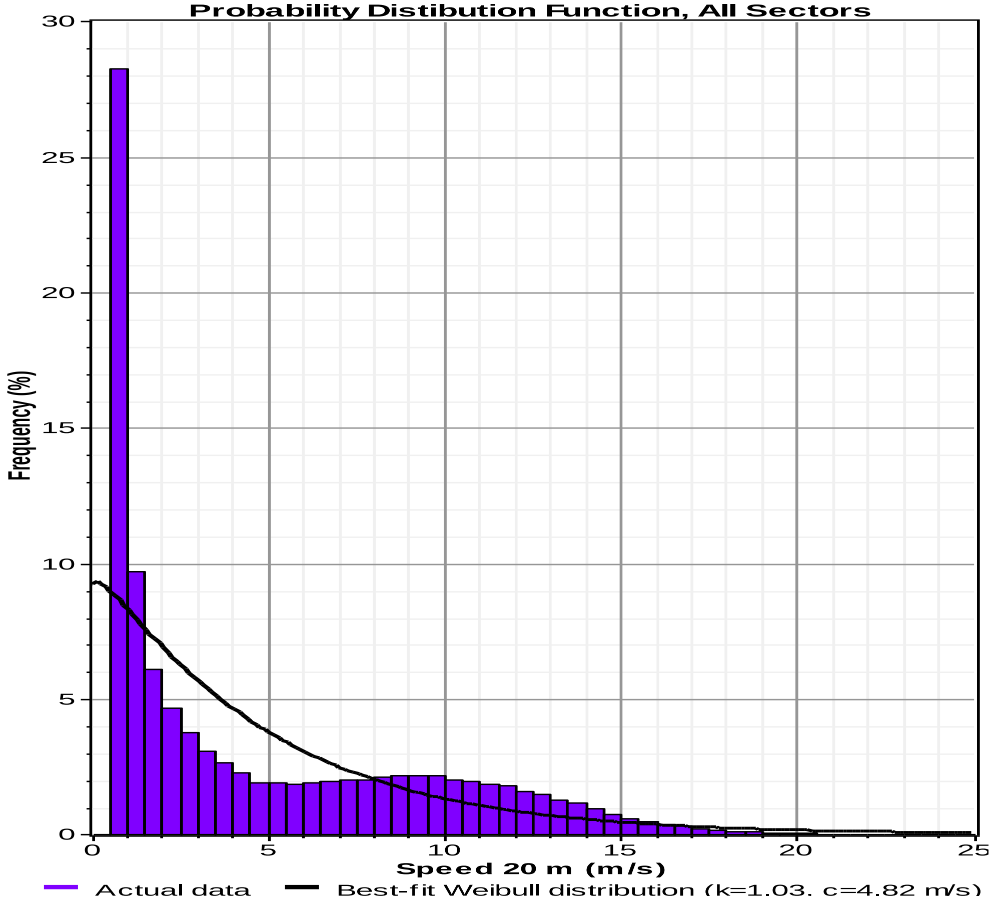


Figure 3-8: Wind Speed Distribution at Damphu



A very high percentage of time is characterized by no wind (28%) or low wind speeds. The data indicate that wind speed is less than a typical wind turbine cut-in wind speed (3 m/s) more than 50% of the time. The implication of this is that the wind turbine would be operating on average for only 50% of the time.

3.4.3 Estimates of Energy Outputs

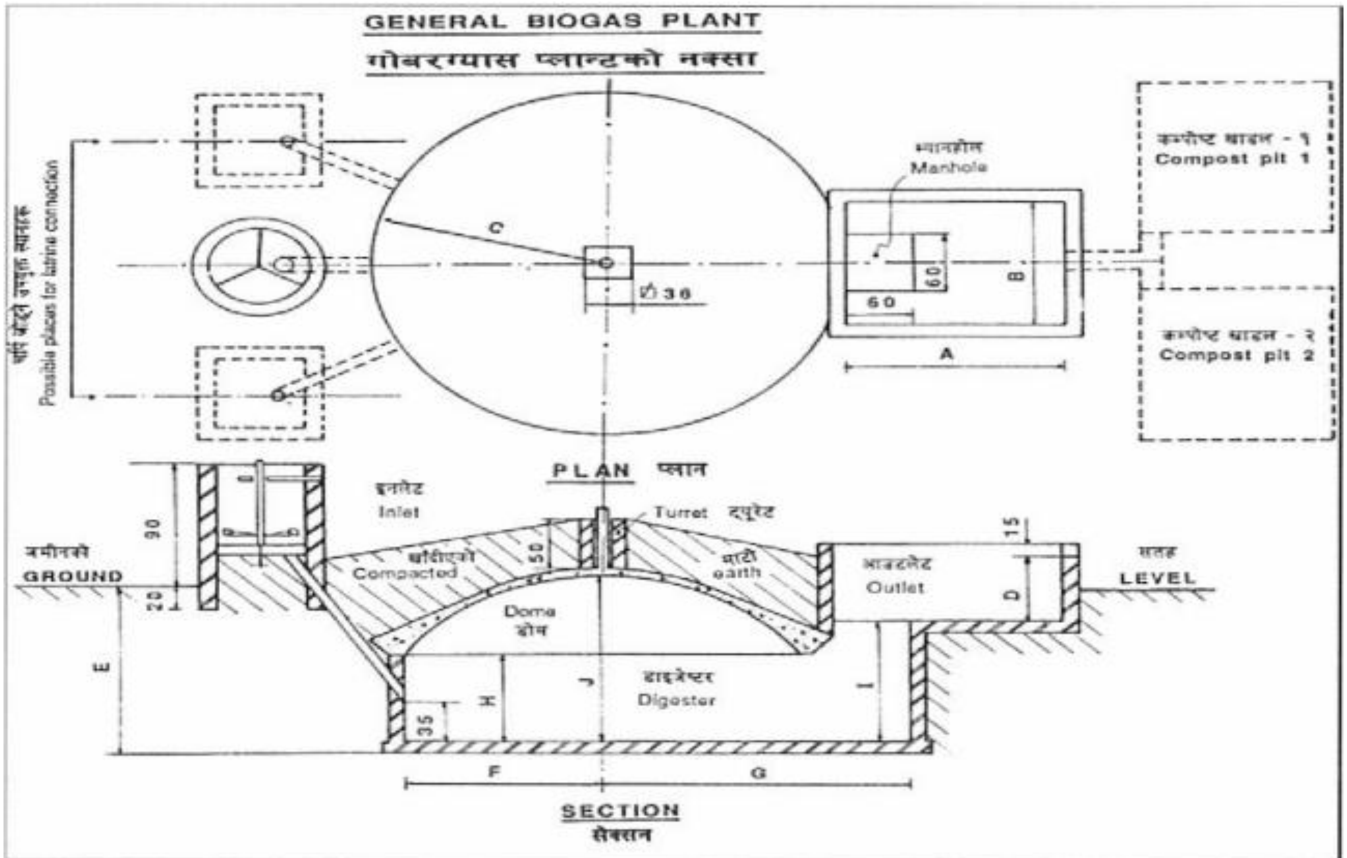
The energy outputs of the two 180 kW wind turbines were estimates assuming 1) the wind resource measured at 20 m Damphu wind mast (2 years), extrapolated to 30 m based on a typical shear exponent of 0.13. This results in an estimated average wind speed of 4.8 m/s at 30 m, and 2) wind farm losses (electrical, wind turbine availability, etc.) of 12.5%, and a reduction of 17% for low air density. Based on these assumptions, the estimated energy outputs would be 0.24 GWh per year per turbine, or 0.48 GWh per year for two turbines, with an estimated capacity factor of 12%. As noted before, once 12-month wind data at Tsimalakha are available, the energy estimates will be updated based on the new wind data.

3.5 PILOT BIOGAS PROJECT

The design of the proposed biogas plants was based on the Feasibility Study of a Biogas Program in Bhutan performed by SNV in December 2008. That study concluded that properly designed biogas plants are technically feasible in areas where the altitude is less than 2,500 meters and winter ambient temperature is not too cold, i.e., above 0° Celsius. The study also concluded that the southern part of Bhutan together with some mountain valleys could be suitable for biogas generation. These include Chukha, Samtse, Sarpang, Tsirang, Mongar, Pemagatshel, Samdrupjonkhar, and Trashigang dzongkhags and Punakha and Wangdue valleys. As a minimum, a household should have 20 kgs of dung per day available (or 4 to 5 cattle) to be feasible for a smallest size biogas plant (4 cubic meters). A 4 cubic meter biogas plant could produce about 0.8 cubic meter of biogas, enough for cooking with a single stove for 3 to 4 hours per day.

For the proposed pilot project, the biogas plants designed by the Gobar Gas Company in Nepal were selected. These are fixed dome-type plants constructed entirely on site using cement, concrete and locally available stones. These plants have been widely used in the mid-hills of Nepal where ambient temperatures are similar to the southern part of Bhutan, and successfully pilot tested in Bhutan. The drawing of a Gobar Gas Company 2047 biogas plant is shown in Figure 3-9.

Figure 3-9: Drawings of Nepal Gobar Gas Company 2047 Biogas Plant



Source: SNV Bhutan

4 FINANCIAL AND ECONOMIC ANALYSIS

This chapter summarizes the financial and economic analysis of the Project. More detailed information can be found in Appendix F: Financial Analysis, and Appendix G: Economic Analysis.

4.1 FINANCIAL ANALYSIS OF THE PROJECT

The financial internal rate of return (FIRR) has been calculated in accordance with the ADB's *Guideline on Financial Management and Analysis of Projects*[18] for the four components of the Project: 1) on-grid rural electrification for 5,075 households, 2) installation of 1,896 solar home systems (SHS) in remote off-grid villages, 3) a pilot biogas project to install 1,600 biogas plants, and 4) installation of 2X180 kW of grid-connected wind turbines as a pilot project. The methodology involves cash flow projections for cost and benefit streams and comparing the resultant FIRR with the weighted average cost of capital (WACC). The key assumptions used were 1) all cash flows are incremental, 2) all prices are at a constant mid-2010 price level, 3) projections are made over a 25-year period with no residual value at the end of 2030, and 4) O&M costs are assumed to be 2% of the original asset value, except for the pilot wind project, which is $10,000 per annum.

Given that the rural domestic tariff does not achieve full cost recovery, the FIRR of the on-grid rural electrification component is negative, although it will clearly have economic benefits. The off-grid solar RE component is aimed at electrifying those households in very remote areas where grid connection is only possible at an exorbitantly high cost. It is therefore understandable that the FIRR of the off-grid RE component is also negative. The FIRR of the pilot biogas component is 7.1%, which indicates that the project is financially viable as it exceeds the WACC. The financial net present value at a WACC of 0.2% amounts to Nu 42 million. The sensitivity analysis indicates that the FIRR still exceeds WACC where 1) costs increases by 10%, 2) revenues decrease by 10%, and 3) there is a delay of 1 year. As the wind component is a pilot project aimed at demonstrating the potential of the wind resource towards energy security, the investment cost is provided as a grant to BPC. However, the pilot project will be financially viable, due to the free capital cost.

[18] *Guideline on Financial Management and Analysis of Projects*, Asian Development Bank, 2005.

4.2 FINANCIAL AND OPERATIONAL SUSTAINABILITY

According Bhutan Electricity Authority's (BEA) 2010 to 2013 tariff order for BPC issued in August 2010, the average cost of providing electricity services to low-voltage (LV) domestic households in the 2010 to 2013 period is Nu 4.21 per KWh, while the average LV household tariff is Nu 1.49 per KWh in the fiscal years 2010 to 2011, Nu 1.55 per KWh in 2011 to 2012, and Nu 1.62 per KWh in 2012 to 2013. Recognizing that the tariffs set by the BEA are below the cost of electricity services, the Ministry of Economic Affairs has provided a Nu 944 million per year subsidy to BPC through a reduced royal energy sale price at Nu 0.13 per KWh. With these subsidies, BPC will be able to maintain its financial viability.

To reduce the costs of providing operation and maintenance services to it rural customers, BPC has retrained its customer service employees at Customer Service Centers to perform multiple tasks, including metering, billing, collection, and on-grid distribution O&M. To further cut down the O&M service costs, BPC has started recruiting and training independent village technicians to perform on-grid distribution O&M services in villages that are far from its CSCs. After the training, these village technicians sign a contract with BPC as a contracted technician that they will stay in their own villages to provide the on-grid O&M services for at least five years. At the end of 2009, BPC had 23 village technicians. BPC plans to recruit and train over 100 additional village technicians in 2010 and 2011 to serve the new households to be connected to the grid in the 2010 to 2013 period.

As described earlier, to provide O&M services to the households in off-grid villages electrified with SHS, the DOE will enter an outsourcing agreement with BPC requesting BPC's contracted village technicians to also provide SHS O&M services in neighboring off-grid villages. BPC's personnel at the CSCs or Electricity Service Division offices will provide backup support to village technicians in case they cannot repair the SHS sets. The DOE will provide the necessary training and spare parts to enable village technicians to perform their tasks effectively. To sustain these services, the DOE will assume all the incremental costs of providing SHS O&M services incurred by BPC. The households electrified with SHS typically have little cash income and cannot afford to pay for the SHS O&M and spare part costs. The DOE will seek to fund the SHS O&M services through government budget and revenue from royal energy sales to ensure the long-term sustainability of the SHS O& M services.

For the pilot wind power project, the DOE and BPC will enter an agreement under which BPC will be responsible for procurement, construction, commissioning, and O&M of the pilot wind farm, and the assets will be transferred from the DOE to BPC as a grant. The electricity regulations allow BPC to depreciate the assets. Based on a 5% annual depreciation rate, BPC would receive approximately $22,400 in annual income tax savings, sufficient to offset the annual O&M costs of about $10,000. In addition, BPC is expected to receive about 0.48 GWh of wind power from the project. If this power is priced at Nu 1.55 per KWh, the same as the estimated average LV tariff in 2011, BPC can expect additional revenue of approximately

$16,530 per year. As the pilot project is given as a grant to BPC, the project is financially sustainable.

One of the objectives of the pilot biogas project is to help reduce financial barriers to development of biogas plants in Bhutan. Unlike other capital investment projects, biogas plants are not a direct income producing investment. To overcome the financial barriers, this Project component will provide a subsidy, at 45% of the cost of a typical 4 cubic meter biogas plant, and offer a below-market credit at a 10% interest rate without any collateral requirements. To ensure ownership, a minimum of 27% of the capital costs will be required from the participating farmers. This pilot project will be implemented in phase to facilitate scaled-up implementation and the development of a commercial-driven market in subsequent phases. The subsidy levels can be gradually reduced as the per plant cost decreases in the future.

4.3 FINANCIAL MANAGEMENT ASSESSMENT

The financial management assessment of the EA (DOE), and the IAs (BPC, DOL and BDFC) was carried out using ADB's *Financial Management Assessment Questionnaire*. Overall, financial management of these institutions is satisfactory. DOE and BPC have experience in four similar ADB-funded projects. BDFC is also currently implementing an ADB-funded project. DOE and DOL are audited regularly by the Royal Audit of the RGOB. BPC and BDFC are audited by a private auditor and also by the Royal Audit. BDFC is also audited by the RMA. No material issues have been raised by the auditors and they have confirmed that these organizations maintain an adequate system of internal controls.

4.4 FINANCIAL PERFORMANCE OF THE IMPLEMENTING AGENCIES

4.4.1 Bhutan Power Corporation Limited

BPC is the IA for the on-grid rural electrification and pilot wind power components, as well as the SHS operation and maintenance program of the off-grid rural electrification component. Its financial performance has been evaluated for the past five years and was found to be satisfactory. Its ten-year financial performance was projected based on the demand and supply forecast, capital investment plans, power purchase costs, and other assumptions. Table 4-1 shows the financial projections for BPC from 2010 to 2019.

Table 4-1: Financial Projections for BPC

Item	2010	2012	2015	2018	2019
Energy sales (GWh)	1,492	2,338	2,451	2,601	2,653
Energy wheeled by BPC (GWh)	5,248	4,354	9,898	12,843	17,098
Total revenue (Nu million)	3,078	4,470	5,403	6,131	6,746
Net profit / (loss) (Nu million)	473	353	857	984	1,712

Table 4-1: Financial Projections for BPC					
Item	2010	2012	2015	2018	2019
Average yield (Nu/kWh)	1.58	1.64	1.69	1.74	1.76
Average cost of supply (Nu/kWh)	1.47	1.60	1.60	1.68	1.51
Cost recovery (%)	108%	103%	106%	104%	117%
Return on assets	6%	5%	6%	4%	6%
Debt service coverage ratio	5.1	3.1	2.8	2.8	3.5
Debt/equity ratio	29:71	39:61	46:54	46:54	43:57
Accounts receivable (days)	26	26	26	26	26

As shown, the projected profitability is satisfactory throughout the projection period. The debt to equity ratio and debt service coverage ratio (DSCR) are satisfactory and are in compliance with the loan covenants under the previous Bank-funded rural electrification project, which are 1) DSCR: minimum of 1.5, 2) a debt to equity ratio of 70:30, and 3) an accounts receivable collection of less than two months.

4.4.2 Bhutan Development Finance Corporation Limited

BDFC is the financial intermediary responsible for managing and processing the biogas trust under the pilot biogas project component. The BDFC is a government-owned financial institution established to cater to the needs of micro, small and medium enterprises with a special focus on agricultural development. Its financial performance has been satisfactory in the past five years and its non-performing loans have improved significantly due to more stringent credit appraisal, supervision and monitoring, particularly in 2009. Table 4-2 presents the financial projections for BDFC in the next ten years. As can been seen, BDFC will maintain itself as a financially sound and profitable corporation during the projection period.

Table 4-2: Financial Projections for BFDC					
Item	2010	2012	2015	2018	2019
Loan portfolio (Nu million)	2,948	3,908	5,642	7,876	8,802
Total revenue (Nu million)	412.3	544.1	783.4	1,099.3	1,230.8
Net profit / (loss) (Nu million)	196.8	249.6	418.3	637.6	743.8
Interest spread (%)	7%	7%	7%	7%	7%
Return on assets	10%	10%	11%	13%	14%
Debt service coverage ratio	1.5	2.1	2.7	1.7	1.6
Statutory liquidity ratio	15%	14%	13%	16%	18%
Non-performing loans	12%	11%	9%	9%	9%

4.5 NATIONAL ELECTRICITY DEMAND FORECAST

The growth in Bhutan's demand for electricity averaged 17% per year for the period 2005-2009 and was driven largely by high-voltage (HV) consumption, which grew at 23% per year. By the end of 2009, the BPC had 91,268 customers; industrial clients in the HV category accounted for 73% of national consumption. The rapid growth of industrial consumption has exceeded Bhutan's existing capacity to supply electricity in the dry season, when its generation capacity declines markedly and electricity supply is now being capped by BPC shedding "industrial" loads and by the government limiting licenses for new industries. However, this approach has high economic costs, either by way of lost industrial production or by causing industrialists to invest in captive diesel generation sets.[19] This demand/supply gap will grow until more new hydropower plants come on stream in the middle of the current decade.

Energy sales to residential consumers, however, are not rationed and should continue to grow in line with improvements in the general population's standard of living. During the non-dry seasons, Bhutan has plenty of electricity to meet the projected electricity demand growth of 11% per year in the next several years. More information on electricity demand forecast can be found in Appendix A.

4.6 LEAST-COST ANALYSIS

Bhutan's program for rural electrification is based on providing electricity for all by 2013, using least-cost solutions for economically justified investment. The national Rural Electrification Master Plan prepared in 2005 assessed economic limits for grid extension – the point at which the costs of any further grid extension would exceed the economic benefits. The economics of grid extension have subsequently been reviewed and detailed least-cost investment plans were updated during project preparation. The proposed rural electrification program addresses "the last mile" of rural electrification where households to be electrified are located in very remote villages with very low household density. The costs of materials/equipment transportation to remote mountainous areas will be increased substantially. To help cut costs, this TA has reviewed with BPC plans to incorporate least-cost project designs including use of lighter telescopic poles in lieu of conventional tubular steel poles and light single-phase transformers in place of three-phase transformers. For households beyond the reach of the grid, the provision of SHS is considered to be the only economic option and therefore the least-cost solution.

The most likely "without project" options are small dry cell batteries integrated with diesel generators or micro hydro systems. Both of these "without" project options are problematic given the high costs imposed by isolation, difficulties of access, and low density of households.

[19] Electricity produced by diesel generation sets costs Nu 17 per kWh or more under Bhutanese conditions. The Department of Energy is drafting a captive power generation policy.

For mini hydro, these difficulties would be exacerbated by the costs of developing suitable sites, the absence of technical support and assistance for O&M, the large variations in water flows between the dry and wet seasons, and the very low demand by households for power.

The objective of the pilot wind power component is to lay the groundwork for possible diversification of Bhutan's generation, particularly during the dry season when hydropower generation capacity is much reduced by low river flows. The proposed pilot project involves the purchase of the smallest size grid-connected units available and is thus the least-cost way to provide Bhutan with practical experience in wind farm development and operation, including studies of impacts on the power supply system.

The proposed pilot biogas component will adopt the designs of biogas plants that are widely used in the mid-hills of Nepal, which have ambient temperatures similar to those in the proposed target areas, the southern part and mountain valleys of Bhutan. These biogas plants can be constructed entirely on site using cement, concrete and locally available stones and gravels, and the proposed pilot project will train local masons to construct the least-cost biogas plants.

4.7 ECONOMIC ANALYSIS OF THE PROJECT

An economic analysis was undertaken in accordance with the Asian Development Bank's *Guidelines for the Economic Analysis of Projects* and the Economic Research Division's (ERD's) Technical Note No 3, *Measuring Willingness to Pay for Electricity.* For each of the four Project components, the economic costs and benefits were analyzed. The economic costs are based on the component's capital and O&M costs, excluding price contingencies, taxes and financial charges. The economic benefits of the on-grid rural electrification component include: 1) the incremental benefits to households of increased energy consumption, 2) Bhutan's cost savings from reduced consumption of kerosene, batteries, and fuelwood, and 3) the avoided costs of the "without project" option, i.e., the off-grid solar home systems. The economic benefits of off-grid rural electrification with solar home systems are: 1) savings in the cost of kerosene and dry cell batteries and 2) benefits from improved lighting and mobile phone charger. For the pilot wind power component, the economic benefits will be 1) reduced industrial load shedding in the dry season and 2) increased power exports in the remainder of the year. The economic benefits of the pilot biogas component include: 1) cost savings in kerosene, electricity and LPG used in household cooking, 2) savings in labor spent on collecting firewood, and 3) economic values of the by-product, i.e., bio-slurry fertilizers.

4.7.1 Calculation of the Economic Internal Rates of Return

A period of 25 years was used for the EIRR calculations, with due allowance for residual values of long economic life assets. Table 4-3 shows the results of the EIRRs. Both the Project and all of its individual components are projected to make a positive economic contribution.

Table 4-3: Economic Internal Rate of Return Results

Component	**EIRR**
Rural Electrification (On Grid)	12.7%
On Grid Program (RE plus Wind Power)	12.7%
Solar Home Systems	28.7%
Biogas	14.3%
Aggregate All Components	**13.9%**

Source: Asian Development Bank estimates.

4.7.2 Sensitivity Analysis

A sensitivity analysis of the estimated EIRRs was also carried out against the uncertainties associated with the Project, including cost increases, benefit decreases, and schedule delays. Table 4-4 shows the sensitivity analysis results.

Table 4-4: EIRR Sensitivity Analysis

Item	Variable	EIRR
Base Case		13.9%
Project Cost	+10%	11.8%
Benefits	-10%	11.6%
Time Period	+ 1 year	11.4%

Source: Asian Development Bank estimates.

As shown, EIRRs are acceptable under adverse circumstances with aggregate returns close to the economic hurdle rate of 12%. The returns are most sensitive to time delays on Project completion, especially for the on-grid extension component. The likelihood of delay low, however, because BPC has the experience and resources to complete the Project on time as demonstrated by its timely implementation of three similar ADB-funded RE projects in the past. For the proposed Project, BPC has requested advance procurement and contracting to minimize the risk of time delays.

5 ENVIRONMENTAL IMPACT ASSESSMENT

The Initial Environmental Examination (IEE) was prepared for each Project component in accordance with ADB's *Safeguard Policy Statement (2009)*, RGOB environmental impact assessment guidelines and other policies and legislation.[20] From an environmental standpoint, the Project is classified as a Category B project as it is not expected to result in any adverse irreversible impacts. The Bhutan National Environment Commission (NEC) has granted its environmental clearances for each Project component.

The IEEs identified some temporary, reversible and insignificant impacts of the Project, especially during the construction phase. They include specific environmental management plans to mitigate the identified short-term impacts. The IAs and their subcontractors will be responsible for managing and addressing community, health and safety and labor issues in an appropriate and timely manner, consistent with Bhutanese laws and ADB's Safeguard Requirements. In addition, a "chance find procedures" protocol will be implemented to manage the institutional arrangements required between EA/IAs and the government in the case archeological, cultural, or religious artifacts are encountered in any clearing or excavation work.

5.1 ON-GRID RURAL ELECTRIFICATION COMPONENT

For the on-grid RE component, contractors of civil works will be required to minimize any impacts during the erection of poles, conductors and accessories. BPC has followed the government's laws on acquiring the rights of way: that there are no land acquisitions or resettlements involved. Where distribution lines go through environmentally-sensitive areas such as national parks or biological corridors, covered conductors will be used to minimize potential damages to vegetation. BPC will implement the Environmental Management Plan (EMP) to compensate land owners for any crop damages according to Bhutan's laws. In all, the IEE concluded that there will be no significant environmental impacts during construction and operation phases. BPC has successfully implemented similar ADB-funded rural electrification projects without any significant environmental impacts.

[20] The IEEs for the On-grid Rural Electrification Component were prepared by the BPC with assistance from a national consultant engaged by ADB separately.

5.2 OFF-GRID RURAL ELECTRIFICATION COMPONENT

The IEE concluded that the installation of SHS for households in off-grid villages will not have significant adverse environmental impacts. There will be no construction impacts as no major civil works are involved. The SHS sets are installed at the household's premise, a solar panel mounted on the rooftop or on a pole near the house, and all other components (controller, battery and light bulbs) inside the house. No civil works, ground clearing or excavation will be involved. During the operation phase, solar batteries will need to be replaced every five years. The EMP included in the IEE will require the DOE to make sure all the replaced batteries will be collected from the villages and transported to Phuntsholing, and turned over to entities in India licensed to recycle or dispose used in accordance with Indian law. Thus, the off-grid RE component will not have any significant irreversible environmental impacts. The full IEE for this component is included in Appendix H.

5.3 PILOT WIND POWER COMPONENT

This component will pose temporary impacts during construction. The proposed pilot wind project will be constructed on private land belonging to BPC. It will require clearing an area of about 80 square meters for the wind turbine foundation, and an additional approximately 300 square meters for construction. The BPC has agreed to let the DOE use the land for the proposed project. In addition, the project will require the construction of a new access road about 800 meters long and 5 meters wide. Public consultations were held and the affected land owners have agreed to turn over the land for construction of the access road. They will be provided substitute land per their preference. The IA will ensure the contractor will use the best practices to minimize any short-term impacts from construction such as dust and noise from truck and construction equipment. Compensation for standing crops, if any, at the time of the access road construction will be provided in accordance with Bhutanese laws. In addition, compensation for the preparation of the substituted land will be provided. The Chukha dzongkhag Administration and the DOE/BPC will be in charge of the land substitution exercise and they have the experience and capacity to manage the exercise successfully.

The BPC had initially planned the construction of a new training center at the proposed site. But that plan was cancelled and currently BPC does not have plan for the site. The site is not in an environmentally-sensitive area and there are no known bird migration paths in the area. The nearest house, a single dwelling, is located about 250 meters from the proposed wind turbine location. The noise level at this distance is projected to be below Bhutan's national ambient noise standards of 55 DB(A) during the day and 45 DB(A) at night. Thus, the IEE concluded that no significant environmental impacts from the operation of the proposed wind power project are expected. Appendix I is the IEE for the wind power pilot project component.

5.4 PILOT BIOGAS COMPONENT

The IEE concluded that implementation of the pilot biogas project will be unlikely to produce any significant, irreversible environmental impacts. Individual biogas plants will be built at the premises of the participating farmers, and the key biogas plant components, including the digester and outlet, are built underground. Only the inlet will be built above ground to allow participating framers to mix dung with water to feed into the digester. The plants will be constructed entirely on site using cement, concrete and locally available stones. The by-product, i.e., biogas slurry, can be used as an organic fertilizer to improve crop yields. Thus, no adverse, irreversible environmental impacts are expected from the construction and operation of pilot biogas plants. Appendix J contains the full IEE for this component.

6 POVERTY AND SOCIAL ANALYSIS

The social assessment undertaken for the Project concluded that the Project's Safeguard category is classified as B for involuntary resettlement and C for indigenous people. The results of the poverty and social analysis are summarized in the sections below. No poverty or social impacts are anticipated from the proposed small-scale wind pilot project (360 kW capacity). Appendix K contains the Summary Poverty Reduction and Social Strategy and Gender Action Plan.

6.1 RURAL ELECTRIFICATION

Rural electrification has been an integral part of the RGOB's strategy to reduce poverty and stimulate economic activities in rural areas. The Project will have substantial benefits to the 6,971 households and approximately 38,800 people (5,075 households in the on-grid RE component and 1,896 households in the off-grid RE component) to be electrified. These benefits include: 1) improved lighting in homes, businesses, public service facilities and centers, 2) cleaner air in the household, 3) improved health through a reduction in smoke emitted from firewood stoves and kerosene wick-lamps leading to vision, respiratory and other related ailments, 4) improved education, as better lighting will allow students to study for longer hours, 5) facilitation of household chores, 6) promotion of weaving and other income-generating activities leading to enhanced incomes for men and women, 7) promotion of recreational activities such as reading, watching television, and listening to radio, 8) promotion of social visits and interaction within households and communities in the evenings, 9) improving the quality of religious ceremonies and prayers, 10) improving general health and emergency care of illnesses, particularly at night, 11) reducing the amount of time, effort and money devoted to collecting firewood and kerosene for lighting, heating and cooking purposes, and 12) promotion of small-scale cottage industries, mini-food processing units, mechanized dairy processing units, and other small trades such as carpentry and tailors.

The Project will contribute significantly to poverty reduction and promote equitable rural development. Access to electricity will provide the poor with equal opportunity to enjoy an improved quality of life, facilitating their participation in economic activities that can contribute to poverty alleviation. In terms of gender, women are expected to benefit equally through additional lighting, reduced time spent collecting fuelwood, and the use of rice cookers and other electrical items that will reduce indoor smoke pollution. The provision of clean energy will not only make their chores easier but will also improve their health conditions. Respiratory and eye ailments are more common to women, children and the elderly since these groups remain

indoors more than men. More information can be found in the SPRSS and Gender Action Plan (Appendix K).

In addition, the Project will coordinate with gender empowering activities in the proposed separate regional project for JFPR: Improving Gender Inclusive Access to Renewable Energy in South Asia (Bhutan, Nepal, and Sri Lanka). This is expected to support training programs for the village technicians, who will include female trainees.

6.2 PILOT BIOGAS COMPONENT

This component will help improve the quality of life and health of 1,600 households, or 8,450 people, by introducing modern household cooking methods. Biogas plants will substantially reduce the costs and time spent on collecting firewood for cooking, especially by women. The time saved will enable them to do income generating activities such as picking oranges, growing vegetables, and weaving. The reduced consumption of firewood for cooking will substantially cut down smoke inside houses and the harmful impacts on households. It will also reduce the time needed to clean up cooking pots, utensils, and houses blackened by firewood smokes. The by-product, the bio-slurry, is a potent organic fertilizer that reduces the expenses for chemical fertilizers, or produces incomes when sold to other farmers. This Component will also help create a commercially-driven biogas market and generate jobs for local laborers to help masons build biogas plants and provide O&M services to biogas plants.

6.3 SOCIO-ECONOMIC SURVEY

A comprehensive socio-economic survey was carried out in the December 2009 to February 2010 period. The objectives of the survey were to: 1) gather socio-economic profiles and baseline data on the communities in the proposed Project areas for social and poverty impact analyses, 2) collect information related to socio-economic parameters including energy use patterns of the villages, 3) obtain data for estimating willingness and affordability of households to pay for the electricity or other renewable energy to be provided by the Project, 4) identify any indigenous people in the Project areas for social impact analysis, and 5) conduct public consultations on the proposed biogas pilot project and off-grid RE solar home components.

The survey was carried out through household visits and interviews with the heads of the households. Structured questionnaires were prepared and used as the tool for the field survey. The primary target for the survey was households that had not yet received any electricity as of December 2009 and were proposed to be provided with electricity under the Project. In addition, the survey asked questions regarding the potential for a biogas plant to those households owning more than 5 cattle. The survey was divided into three categories: 1) households targeted for the on-grid electricity supply, 2) households targeted for the off-grid

solar home lighting system installation, and 3) households with the potential for a biogas plant (i.e., having more than 5 cattle).

The survey included un-electrified households in the 6 dzongkhags to be funded by the Project, and other 13 dzongkhags to be covered by JICA and the Austrian Development Agency. A random sampling method of 20% of the total number of households to be electrified was used to arrive at the final samples of villages/households for the survey. These included 1,609 households for the on-grid RE component and 358 households for the off-grid RE component. More detailed information can be found in Appendix L. The key findings of the survey are summarized below.

- Off-farm labor, livestock and farming are the main economic activities of the surveyed households. Remittances and skilled labor such as carpentry, masonry and painting/carving also constitute other important sources of income.

- Access to basic services and amenities is poor amongst the communities surveyed.

- The main fuels used for cooking are: firewood (98.17%) and LPG (1.83%). Kerosene is also used as a secondary and tertiary source of energy for cooking (13.17% secondary and 2.80% tertiary).

- For lighting 95.12% use kerosene as the primary source while the rest use firewood, LPG candles and even pine shavings.

- On average, households spend around 54 minutes every day on firewood collection and when converted into monetary terms, each household spends about Nu 22 per day on firewood.

- The average household land holding size is less than an acre for 16.42% of the surveyed population. 18% own between 2 to 3 acres and 8.13% own more than 10 acres.

- 777 households reported having income from off farm labor, while 698 households reported having income from livestock and 631 from agriculture. On the expenditure side, food is the main item the households spend money on, followed by clothing and education.

- 43.32% of the households surveyed fall below the national poverty line of Nu 1,097 per person per month.

- Food security is a problem in the surveyed communities where 24.86% of the surveyed population faces food shortages ranging from 1 month to all year round.

- 98.68% of the total surveyed households (1,967) reported preferring an on-grid connection for electricity while only 1.32% reported preferring an off-grid solar home system.

For the 1,609 on-grid targeted households, 94.22% of those surveyed reported their ability and willingness to spend up to Nu 5,000 for internal house wiring; 5.78% reported that they will not be able to spend as much. In terms of monthly electricity bills, 8.70% of the surveyed households reported being able to pay Nu 30 per month, while 10.19% reported being able to pay above Nu 200 per month. The rest of the households reported their ability to pay as between Nu 30 and 200 per month. Similarly, for the 358 households targeted for SHLS, only 1% of those surveyed reported their ability to pay the actual cost of the SHLS, which was estimated at about Nu 26,000 to 30,000. 9% of the households reported not being able to pay any amount.

Appendix A

SUMMARY POWER SECTOR ASSESSMENT

1. SECTOR PERFORMANCE, PROBLEMS, AND OPPORTUNITIES

1. Bhutan went through a major restructuring to separate commercial management and ownership of the power sector in 2002. At present, the Department of Energy (DOE), under the Ministry of Economic Affairs, is the policy making body for the energy sector, including renewable energy. The state-owned Bhutan Power Corporation (BPC) is responsible for the construction and operation of electrical networks for the sale of electricity, the wheeling of electricity for export, and the construction of embedded generation plants. The Druk Green Power Corporation (DGPC), another state-own corporation, is the holding company of all existing hydropower companies. As the power sector's regulator, Bhutan Electricity Authority (BEA) is responsible for setting tariffs including subsidies, establishing and enforcing technical, safety, and operation standards, issuing and monitoring licenses, and other regulatory functions.

2. Bhutan relies almost exclusively on hydropower for its power generation. The total installed capacity of the existing hydropower plants is 1,488 MW. All of the existing plants are run-of-river types whose total generation capacity drops drastically to 288 MW during winter dry seasons (December through March). If any of the main hydropower plants undergoes downtime for repair, the total firm generation capacity will drop below 200 MW. This low firm capacity cannot meet the system peak demand during winter dry seasons. The winter power shortages will worsen in the next several years until 2016 when the Punatsangchhu-I hydropower plant (1,200 MW) is expected to come on line. In 2008, Bhutan agreed to develop 10,000 MW with India by the year 2020.

3. Table A-1 shows BPC's winter peak demands recorded in the last five years and forecast for the next five years. The winter peak demand has been growing at 17% annually over the period 2005 to 2009, and is expected to reach 300 MW in the winter of 2010, exceeding the system's maximum firm power generation capacity of 288 MW. In the 2010 winter, about 25 MW of existing industrial loads would be curtailed, as stipulated in BPC's power supply agreements. Power imports from India, especially in the winter months, will become increasingly difficult to arrange as India has its own power shortage problems in the winter months. As shown in Table A-1, the winter system demand from industrial customers would

have to be reduced by 6% annually in the 2010 to 2015 period to avoid any load shedding of the domestic peak demand.

4. Due to this winter power shortage problem, BPC is not expected to connect any new industrial customers in the next five years. The Department of Industries has declined a number of license applications from industries due to the winter power shortage problems, resulting in adverse impacts on the nation's economic development. It should be noted that during the wet seasons, existing hydropower plants can generate sufficient electricity to meet the domestic and industrial demands and for power export. Thus, BPC's annual electricity sales (in GWh) are expected to continue growing at 11% per year in the next few years despite the winter power shortages.

Table A-1. Demand and Supply of the Power Sector in Bhutan

	2005	2006	2007	2008	2009	Growth ('05-'09) (% / Yr)	2010	2011	2012	2013	2014	2015	Growth ('10-'15) (% / yr)
Winter Peak Demand (MW)													
Domestic	56	60	65	72	80	9%	85	95	105	117	130	145	11%
Industry & construction(Curtailed)	69	70	92	115	157	23%	203	193	183	171	161	146	-6%
Total Winter Peak Demand (Curtailed)	125	130	157	187	237	17%	288	288	288	288	291	291	0%
Hydropower Capacity (MW)													
Installed Capacity	468	638	1488	1488	1488	34%	1488	1488	1488	1602	1602	1602	1%
Maximum Firm Capacity (dry season)	118	146	288	288	288	25%	288	288	288	288	291	291	0%
BPC Electricity Sales (GWH)													
LV retail sales	190	215	231	259	275	10%	345	411	457	489	525	570	11%
HV/MV industries	429	445	671	813	1069	26%	1147	1723	1881	1881	1,906	1,906	11%
Total Sales	619	660	902	1072	1344	21%	1492	2134	2338	2370	2,431	2,476	11%
Source: BPC, adjsuted by the Consultant													

5. To alleviate poverty and stimulate economic and social development, the government had started large-scale rural electrification projects during the nation's sixth Five-Year Plan (1988 to 1993). All the subsequent five-year plans have included rural electrification as one of their key elements.

6. ADB has been the key sponsor for Bhutan's rural electrification program since 1995. The three ADB-financed rural electrification projects that have been completed, together with the on-going one (2009 to 2013) will have electrified close to 30,000 households, or 35% of the rural households in Bhutan. At the end of 2009, the nation's electrification rate reached 60%. The government has established an ambitious goal of providing electricity for all within the 10th Five-Year Plan. Under the proposed Project, ADB will finance the on-grid rural electrification of 5,075 households and off-grid rural electrification of 1,896 households with solar home systems.

7. As rural electrification is extending to more remote areas with more difficult terrain and lower household density, the electrification cost per household will inevitably increase. The average electrification cost per household for the first three ADB-financed projects was about $2,000 (adjusted to 2010 dollars). The average cost of subsequent rural electrifications is over $3,000 per household. It is thus essential for the BPC to incorporate cost savings designs such as telescopic poles and single-phase transformers to reduce the cost of rural electrification.

8. In addition, households in remote villages where it is not technically or economically feasible for on-grid rural electrification are provided with electricity supply mainly through solar home systems (SHS). In the past, various donor organizations and the government had installed SHS for households in remote off-grid villages. The DOE recently estimated that about 2,500 solar home lighting systems will have been installed by the end of 2010. The most important lessons learned from off-grid SHS projects are: 1) the design and specification of SHS should be carefully developed to minimize the downstream service requirements, 2) household owners should be trained on the use and simple care of the SHS, 3) long-term operation and maintenance services with qualified village-based technicians are essential, and 4) spare parts and replacement batteries should be made affordable to poor households and available in a timely manner. To ensure the long-term sustainability of solar home systems for households in remote off-grid villages, an effective long-term O&M arrangement must be built in the installation of solar home systems.

9. Wind power projects have the potential to generate clean energy to supplement the diminishing hydropower in the winter dry seasons. In addition to the existing metrological stations, the DOE has recently installed wind masts at three additional sites to collect wind data for more accurate assessments of wind power potential and the development of wind farms. As wind power technology is new to Bhutan, it is important for Bhutan to build capacity and strengthen institutions in designing, constructing and operating wind farms in order to realize wind power potential in Bhutan. Further, it is necessary to establish a national policy to promote and develop renewable energy and provide financial and fiscal incentives to help overcome financial barriers to wind power development.

10. Bhutan has been consuming about 1.0 to 1.2 million tons of fuelwood per year; about 70% of this amount is used by households for cooking and heating. Bhutan's fuel consumption of about 1.2 tons per capita per year is among the highest in the world. In addition, Bhutan has been importing large quantities of fossil fuels – 5.7 million tons of LPG and 5.2 million tons of kerosene in 2008 – for cooking, heating and lighting.

11. Biogas was first introduced in Bhutan in the 1980s as a clean and renewable energy source for household cooking to help cut down firewood consumption. However, most biogas technologies have been abandoned due to poor technical design and lack of spare parts, repair and maintenance. To assess the biogas market potential in Bhutan, SNV, Netherlands Development Organization, conducted technical feasibility studies,[21] and ADB subsequently undertook the market assessment studies with SNV.[22] These studies have concluded that there are at least 16,000 households that have the potential to use biogas plants cost-effectively. The studies also assessed the major technological, financial, informational, and institutional barriers to biogas development. To realize the untapped biogas potential, the biogas development program must incorporate 1) financial incentives to help overcome the financial barriers, 2)

[21] SNV. 2008. *Feasibility of a Biogas Programme in Bhutan*. Bangladesh.
[22] ADB. 2008. *Regional Technical Assistance for Electricity for All Initiative*. Manila.

selection of biogas designs that work well in high-altitude areas, 3) capacity building and institutional strengthening to help create a private sector-driven biogas market, and 4) promotional marketing to help overcome informational barrier to farmers.

2. THE GOVERNMENT'S SECTOR STRATEGY

12. Rural electrification (RE) has been an integral part of Bhutan's national development strategy. RE helps reduce poverty and improve the quality of life for households in rural areas. Since 1988, the government has been promoting RE programs as a high development priority, and in 2008 decided to accelerate the target of providing electricity for all from 2020 to 2013. It has been the government's strategy to use a mix of renewable energy – including large hydropower plants, micro hydro stations, wind power, and solar energy – to electrify rural households. While rural electrification is aimed at those households within a reasonable distance from the power supply point; the solar home lighting component is aimed at households that are very remote and whose connection to the grid is economically not viable.

13. Recognizing that the nation's electricity generation almost exclusively relies on hydropower and the on-going problems of meeting peak power demand in dry season, the DOE is in the process of developing and approving a national Renewable Energy Policy.[23] This policy's key objectives will be to diversify the energy resource mix to enhance long-term energy security, reduce the need for fossil fuel imports, reduce greenhouse gas emissions, and stimulate social and economic development through efficient renewable energy interventions and private sector participation.

14. To execute this policy, Bhutan must overcome a number of barriers such as high production costs and low electricity tariffs in order to develop renewable energy including solar, wind and biogas energy. Without clear government policy support, heavy subsidy and financial incentives, especially in the initial phase of the development, few wind, solar or biogas energy projects would be financially viable. Solar energy has been explored only by installing stand-alone solar home systems to provide lighting services to remote communities where providing on-grid electricity is not feasible. So far, the total installed capacity of solar home systems has been a marginal part of the country's generation capacity. While the National Renewable Energy Laboratory under the U.S. Department of Energy provided the country-wide wind data mapping assessment, more comprehensive programs to measure actual wind data, quantify wind resources potential, and identify suitable wind farm site inventories will need to be carried out to exploit wind power potential. Biogas had been tried in 1980s without any long-term success. But recent studies have estimated that about 16,000 households have the potential to use renewable biogas cost-effectively.

[23] ADB TA 7157-BHU: Promotion of Clean Power Export Development, 2008. This TA has helped the government draft the Renewable Energy Policy. This support is also in line with the recommendations from *the Sector Assistance Program Evaluation for Bhutan* (ADB. 2010. Manila).

15. To provide funding for promoting and developing renewable energy, the Sustainable Hydropower Development Policy of 2008 has provided guidelines on the creation of Renewable Energy Development Fund. This policy also directs that the Fund be used to undertake the development of RE and environmental services of large hydropower projects. In addition, the Economic Development Policy of 2010 requires that generating companies provide 15% of the power generated from medium, large and mega hydropower projects as free royalty energy (see Appendix F) to the government, and stipulates the benefits from the sale of the royalty energy to BPC be used to provide electricity tariff subsidies to low-voltage consumers, support RE initiatives, and conserve the catchment area of hydropower project.

3. ADB SECTOR EXPERIENCE AND ASSISTANCE PROGRAM

16. ADB and the governments of Austria, Japan and Netherlands have been actively supporting rural electrification in Bhutan, with ADB being the leading agency. Bhutan has improved the electrification ratio from 24% in 1999 to 60% in 2009. Since 1995, ADB has provided three loans and one grant for rural electrification projects, covering 30,000 households, or about 35% of the rural population. With parallel financing from the Austrian Development Agency and the Japan International Cooperation Agency, the proposed Project will support the government in achieving electricity for all.

17. ADB has also been actively supporting power sector restructuring, institutional strengthening, and capacity building. Its technical assistance has been highly effective in transforming the power sector from a government department into a profitable utility and an independent regulator, and employing state-of-the-art utility management practices. Since 1995, ADB has provided 13 technical assistance grants, including the on-going TA 7156-BHU: Promotion of Clean Power Expert Development (2008) that has helped the government draft its Renewable Energy Policy. All these loans and technical assistance grants are fully aligned with the country partnership strategy made between ADB and the government.

Figure A-1: Problem Tree for the Power Sector

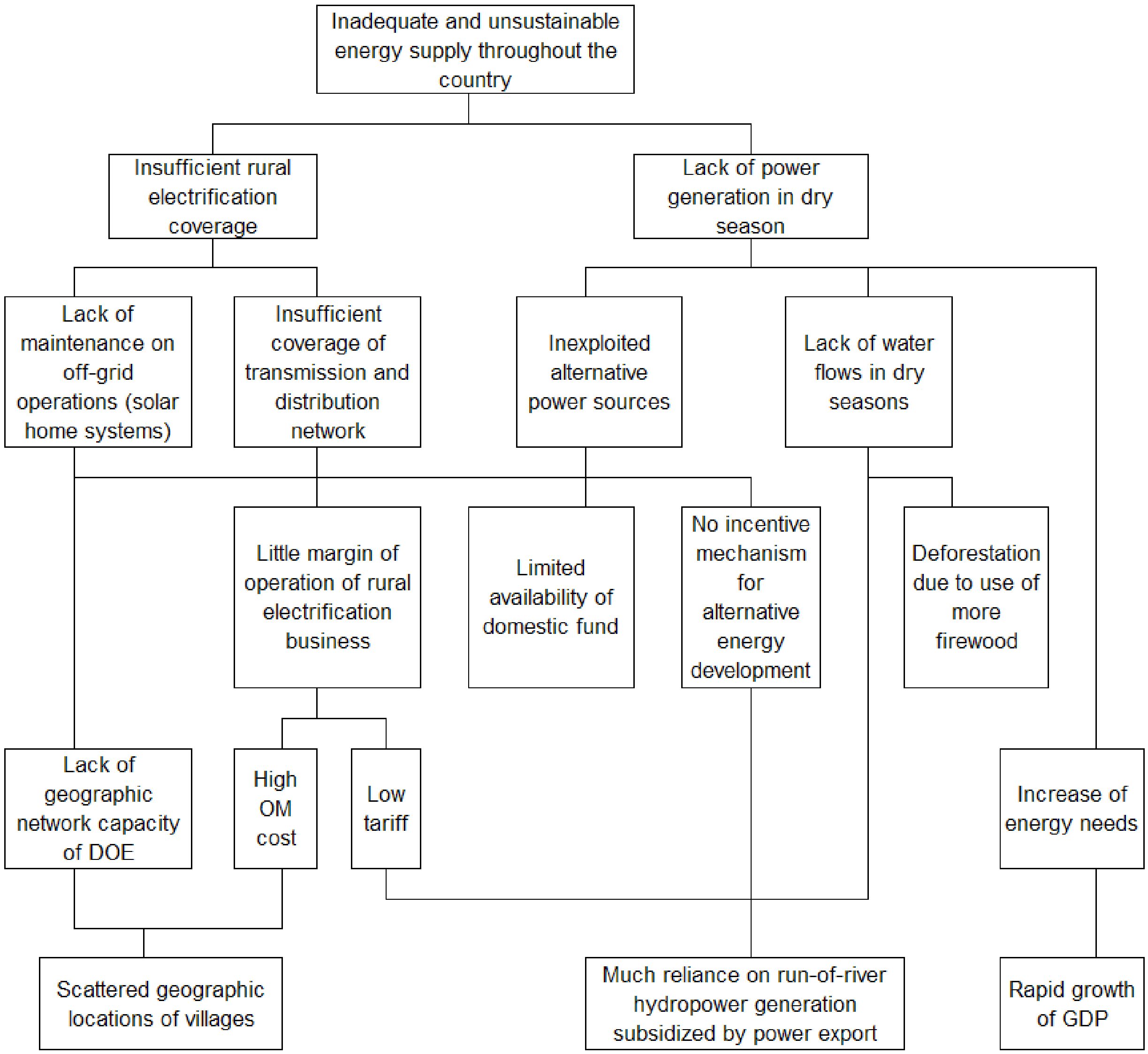


Table A-1: Sector Results Framework (Energy, 2010–2020)					
Country Sector Outcome		**Country Sector Outputs**		**ADB Sector Operations**	
Outcomes with ADB Contributions	**Indicators with Targets and Baselines**	**Outputs with ADB Contributions**	**Indicators with Incremental Targets** (baselines Zero)	**Planned and Outgoing ADB Interventions**	**Main Outputs Expected from ADB Contributions**
Increased energy access for rural households Accelerated large hydropower development and its power export Increased alternative renewable energy development	100% rural electrification by 2013 (2009: 60%) Additional 10,000 MW hydropower plant constructed by 2020 (2009: 1,488 MW) Additional 70 MW alternative renewable energy by 2020 (2009: 0.01 MW)	More coverage in distribution expansion and connections to rural households More installments of solar home systems in off-grid rural villages More village technicians to support community-based management in rural electrification (including employment of more women village technicians) More investment in large hydropower development More public-private-partnerships in hydropower export development More inventories of renewable energy generation such as wind, solar, micro/mini	Grid connections of an additional 8,959 rural households by 2013 Installation of an additional 1,896 solar home systems in off-grid rural villages Electricity access increased from 60% (2009) to 100% of households by 2013 Installation of 16,000 biogas plants by 2020 Installation of 70 MW of alternative renewable energy generation sourced from wind, solar, mini/micro hydro, and biomass by 2020 Deployment of 120 village technicians including 40% female by 2013 Development of 10,000 MW large hydropower plants, mainly for power export by 2016	**Planned Key Activity Areas:** - On-grid rural electrification - Off-grid solar rural electrification - Wind power generation mills - Biogas plants **Projects in the Pipeline:** - Large hydropower export project based on PPP model - TA support for rules and regulations, inventory plan for renewable energy development **Ongoing Projects:** - On-grid rural electrification ($25.28 million) - Off-grid solar rural electrification ($1 million) - Large hydropower generation (114 MW,	5,075 new households on on-grid extension Installation of 1,896 new solar home systems and rehabilitation of the existing 2,500 units 360 kW wind power generation 1,600 biogas plants 210 MW hydropower for export Renewable energy master plan Around 9,000 new households 119 public facilities such as schools, clinics, and community facilities in off-grid villages 114 MW hydropower Enterprise

Table A-1: Sector Results Framework (Energy, 2010–2020)					
		hydropower development sites Private participation in alternative renewable energy development Modernized institutional systems of utilities		$80 million) - TA: Institutional capacity development of the hydropower sector Renewable energy and captive power policies	resources planning systems Corporate guidelines and manuals Renewable Energy Policy Captive Power Policy

ADB = Asian Development Bank
MW = megawatt,
PPP = public private partnership
TA = technical assistance.
Sources: Asian Development Bank and government agencies.

Appendix B

PROJECT DESIGN AND MONITORING FRAMEWORK

Design Summary	Performance Targets/Indicators	Data Sources/Reporting Mechanisms	Assumptions and Risks
Impact Sustained inclusive economic growth through reliable and affordable clean energy services	Increase in the energy sector's share of GDP from 25% to 40% (2017) Reduced proportion of people living below the national poverty line from 23.2% to 20% by 2015 Diversification of energy supply sources through renewable energy including solar, wind, and biogas up to 70 MW equivalent by 2020 Maintained proportion of forestry area (72.5%) in the country Reduction of domestic use of fuelwood by 30% from the 2005 consumption level by 2020	Government statistical and census reports Government five-year plans UNDP Bhutan Annual Report (for Millennium Development Goals) Economic reports of Government, ADB, IMF, and World Bank	**Assumptions** • Government's high policy priority and firm investment to rural development and poverty reduction • Stable macroeconomic growth in South Asia • Renewable energy technology improvement and capital cost decrease • Issuance and execution of Renewable Energy Policy • Government's policy for forestry conservation **Risks** • Exogenous economic and political shocks
Outcome Expanded coverage and mix of clean energy supply in a sustainable manner	Increase in access to electricity by rural and urban households, achieving a cumulative national electrification ratio from 54% (2008) to 100% (2013) of all households	Project completion report Audit financial accounts and reports National statistics	**Assumptions** • Government's commitment to promote development for rural electrification and renewable energy development • Government's commitment and framework to ensure BPC's cost recovery

Design Summary	Performance Targets/Indicators	Data Sources/Reporting Mechanisms	Assumptions and Risks
	Access to clean renewable energy sources to all off-grid rural households by 2013 BPC's financial health including sufficient debt service coverage (minimum 1.2) and net profit generation Deployment of over 120 rural village technicians including 40% female by 2013 Reduction of emission gas equivalent to CO_2 by 25,000 tons per annum[1]	Government's fiscal statements Economic reports of Government, ADB, IMF, and World Bank NEC's monitoring report	• Timely implementation of ongoing projects for rural electrification • ADA's and JICA's parallel financing and continuous support for rural electrification **Risks** • Natural disaster
Outputs 1. On-grid rural electrification sourced from hydropower, and its related skills training and livelihood improvement activities[2] 2. Off-grid rural electrification sourced from solar power, and its related skill training and livelihood improvement activities[2] 3. Wind power	Provision of reliable power supply sourced from hydropower through grid extensions to 5,075 households by 2013 [with target: 30% households headed by women] Installation of solar home systems for 1,896 new households by 2013 [with target: 30% households headed by women] Rehabilitation of 2,500 existing solar home systems by 2014 Training of 120 village technicians including 40% female for operation and maintenance for on-grid and off grid rural electrification by 2013[2] Livelihood improvement	ADB review missions' aide memoires Quarterly project progress reports Project completion report Withdrawal applications, and disbursement and contract award records Audit of financial accounts and reports Government's fiscal statement	**Assumptions** • Government's commitment to carry out the Project • Timely mobilization of the Government's counterpart funds • High quality of consultancy services for implementation support • Accessibility to the development sites • ADA's and JICA's parallel finance in a timely manner • SNV's support for biogas capacity building • Training program for village technicians and livelihood improvement activities to be provided from the Improving Gender Inclusive Access to Clean and Renewable Energy in Bhutan, Nepal, and Sri Lanka **Risks** • Unexpected cost increases in commodities and raw materials beyond contingencies • Construction delays due to slow

Design Summary	Performance Targets/Indicators	Data Sources/Reporting Mechanisms	Assumptions and Risks
generation plants 4. Domestic biogas plants	programs to 200 women in the project area by 2014[2] Distribution of 4,500 user manuals for safety and operation awareness of solar home systems[2] Construction of wind power mills with a capacity of 360 kW on a pilot basis and installation of three wind masts by 2014 Construction of 1,600 domestic biogas plants on a pilot basis by 2014		procurement, design changes, or natural disaster • Lack of sufficient and appropriate human resources and expertise
Activities with Milestones 1. Finalization of technical specifications and cost estimates by Aug 2010 2. Issuance of environmental clearances by June 2010 3. Commencement of advance procurement by the fourth quarter of 2010 4. Contract award by the first quarter of 2011 5. Consultant hiring for the solar, wind and biogas components by the first quarter of 2011 6. All planned contract award by 2012 7. All planned manufacturing and delivery by 2013 8. Completion of overall physical construction by 2015			**Inputs** ($ million) (including contingencies) • ADB: $21.59 • Government/BPC: $2.75 • SNV: $0.27 • Users contribution: $0.30

Notes:

[1] JICA. 2010. *Survey on Preparing a Project Design Document of Clean Development Mechanism for Rural Electrification of Bhutan*. Tokyo. The GHG emission reduction was studied in preparing a project design document, after aggregating estimates from ongoing and proposed rural electrification projects of both JICA and ADB. Benefits from other renewable energy components under the project were also added.

[2] The gender-inclusive design is related to the project's major output of rural electrification on an-grid and off-grid basis which will cover more than 80% of the Project's cost. This gender-related output is expected to be supported and monitored by the gender mainstreaming initiative of the Improving Gender-inclusive Access to Clean and Renewable Energy in Bhutan, Nepal, and Sri Lanka, which is being considered separately for approval.

ADA = Austrian Development Agency, ADB = Asian Development Bank, BPC = Bhutan Power Corporation, GDP = gross domestic product, IMF International Monetary Fund, JICA = Japan International Cooperation Agency, NEC = National Environment Commission, UNDP = the United Nations Development Programme.

Appendix C
PROJECT ADMINISTRATION MANUAL

1. PROJECT DESCRIPTION

1. **Project Rationale.** The Rural Renewable Energy Development Project (the Project) will help Bhutan expand rural electrification for all households, and sustain its operations and energy security through a mix of clean energy supply sourced from hydropower, solar, wind, and biogas. The Project has four components: 1) on-grid rural electrification (RE), 2) off-grid solar RE, 3) establishment and grid-connection of pilot wind power generation mills, and 4) a pilot program to promote biogas plants. The project areas are scattered throughout the country and the executing agency will be the Department of Energy, Ministry of Economic Affairs.

2. **Impact and Outcome.** The impact of the Project is to sustain inclusive economic growth through widening the access to reliable and affordable clean energy services. As an outcome, the coverage and mix of clean energy supply will be expanded throughout the country in a sustainable manner. Particularly, the Project will contribute to achieving 100% rural electrification of all households identified in the Rural Electrification Master Plan 2005, and diversifying energy supply sources to meet a growing demand, particularly in the winter dry seasons.

3. **Outputs.** The Project will have one main output for each of its four components:

1) On-grid rural electrification sourced from hydropower (5,075 new households)[24]
2) Off-grid rural electrification sourced from solar power (installation of 1,896 new solar home systems and rehabilitation of 2,500 existing units throughout the country)
3) Pilot wind power generation plants (360 kW) connected to grids[25]
4) Pilot domestic biogas plants (1,600 new plants).[26]

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[24] ADB will cover six dzongkhags: Lhuentse, Mongar, Samdrup Jongkhar, Trashigang, Trashiyangtse, and Zhemgang.
[25] Tshimalakha in Chukha has been selected as a pilot project site for wind power generation, based on the site selection criteria. The maximum capacity of the two wind turbines will be 360 kW with 10-m long blades.
[26] The pilot target areas include Chukha, Samtse, Tsirang, and Sarpang. These dzongkhags were selected as high potential areas for biogas under the market assessment conducted by the Energy for All Initiative (ADB. 2008. Manila). While the assessment concluded there would be a potential of 16,000 users, the other eight dzongkhags were excluded from the main target of the Project, to narrow down the pilot project scope.

2. IMPLEMENTATION PLANS

4. The Project will be processed during 2010 and implemented over five years. It will be completed by 30 June 2015 and the grant closing will be 31 December 2015. The Project's milestones of readiness activities and implementation schedule are shown in Table C-1.

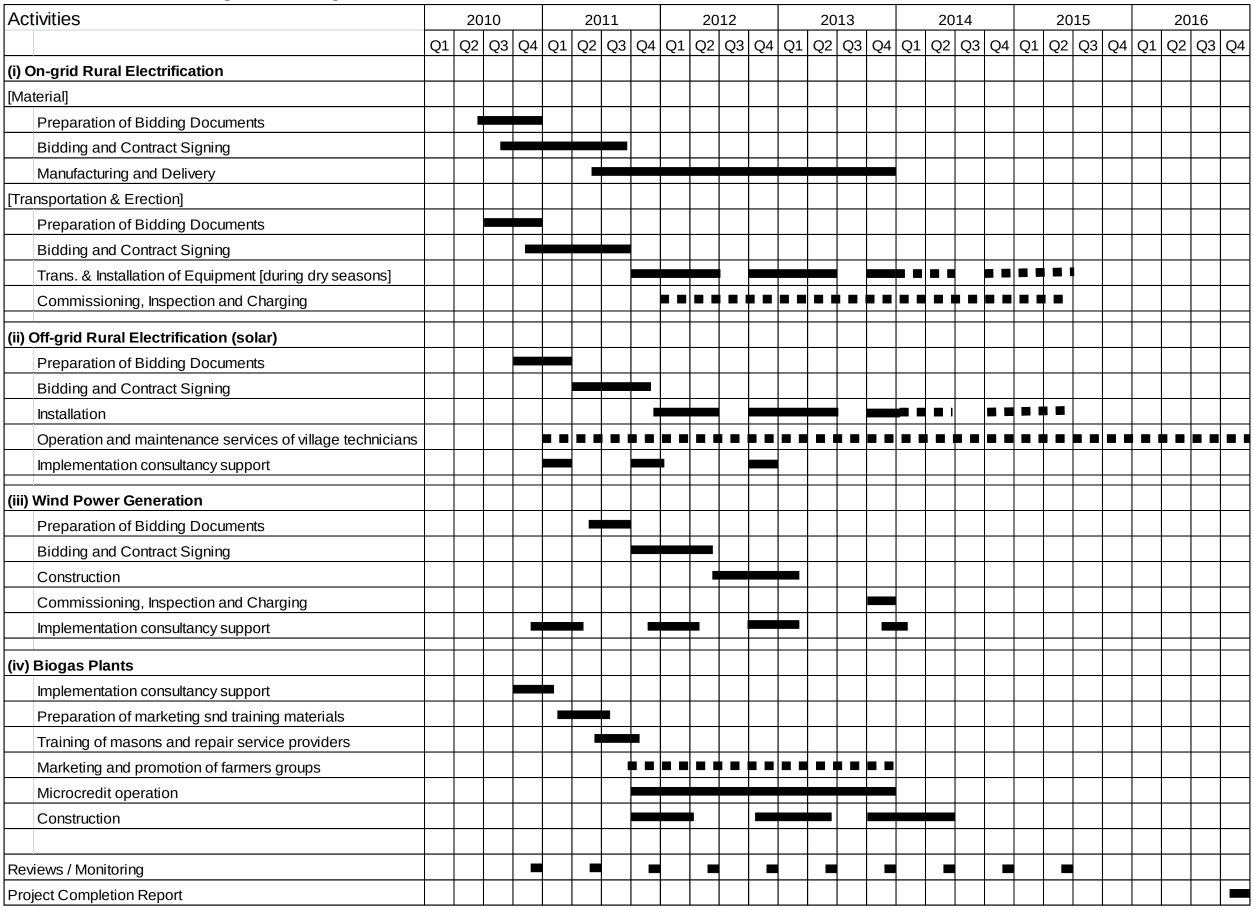
2.1 Project Readiness Activities

Table C-1: Project Readiness Activities

	Months (2010-2011)								
Indicative Activities	**1 Jun**	**2 Jul**	**3 Aug**	**4 Sep**	**5 Oct**	**6 Nov**	**7 Dec**	**8 Jan**	**Who responsible**
Advance contracting actions				x					BPC and ADB
Establish project implementation arrangements			X						DOE, DOL, BPC, BDFC, SNV
ADB Board approval					X				ADB
Grant signing							X		MOF and ADB
Government legal opinion provided							X		MOF
Government budget inclusion	X								MOF, DOE, DOL, BPC, BDFC
Grant effectiveness								X	MOF and ADB

ADB = Asian Development Bank, BDFC = Bhutan Development Finance Corporation, BPC = Bhutan Power Corporation, DOE = Department of Energy, DOL = Department of Livestock, MOF = Ministry of Finance.
Source: Asian Development Bank

2.2 Overall Project Implementation Schedule



3. PROJECT MANAGEMENT ARRANGEMENTS

3.1 Project Stakeholders: Roles and Responsibilities

Project Stakeholders	Management Roles and Responsibilities
Executing Agencies: Department of Energy (DOE)	Responsible for supervising and monitoring of project implementation
Project Implementation Unit	Responsible for implementing each of the Project components through the project implementation units (PIUs)
Project Steering Committee	To promote and facilitate overall project coordination for smooth project implementation
Asian Development Bank	Will undertake regular project reviews and facilitate in project implementation

3.2 Key Persons Involved in Implementation

Executing Agency	
Department of Energy (DOE)	Mr. Yeshi Wangdi Director General Tel No.: (+975) 2-322505 Fax No.: (+975) 2-335122 E-mail: ywangdi@druknet.bt
Implementing Agencies	
Bhutan Power Corporation, Ltd. (for the on-grid RE and pilot wind power components) Department of Livestock (for the pilot biogas component) Department of Energy (DOE) (for the off-grid RE component) Bhutan Development Finance Corporation, Ltd. (for the pilot biogas component)	Dasho Bharat Tamang Managing Director Tel No.: (+975) 2-325095 Fax No.: (+975) 2-322279 E-mail: mdbpc@bpc.bt Mr. Tenzin Dhendup Director General Tel No.: (+975) 2-323146 Fax No.: (+975) 2-322094 E-mail: t-dhendup@moa.govt.bt Mr. Yeshi Wangdi Director General Tel No.: (+975) 2-322505 Fax No.: (+975) 2-335122 E-mail: ywangdi@druknet.bt Mr. Nawang Gyetse Managing Director Tel No.: (+975) 2-323424 Fax No.: (+975) 2-323428 E-mail: bdfced@druknet.bt
Asian Development Bank	
Division Director	Mr. Yongping Zhai Director, Energy Division Tel No.: (63-2) 632-6425 E-mail: yzhai@ad.org
Mission Leader	Mr. Kaoru Ogino Senior Energy Specialist Tel No.: (63-2) 632-5479 E-mail: kogino@adb.org
Project Officer	Mr. Hiroki Kobayashi Senior Energy Specialist Tel No.: (63-2) 632-5021 E-mail: hkobayashi@adb.org

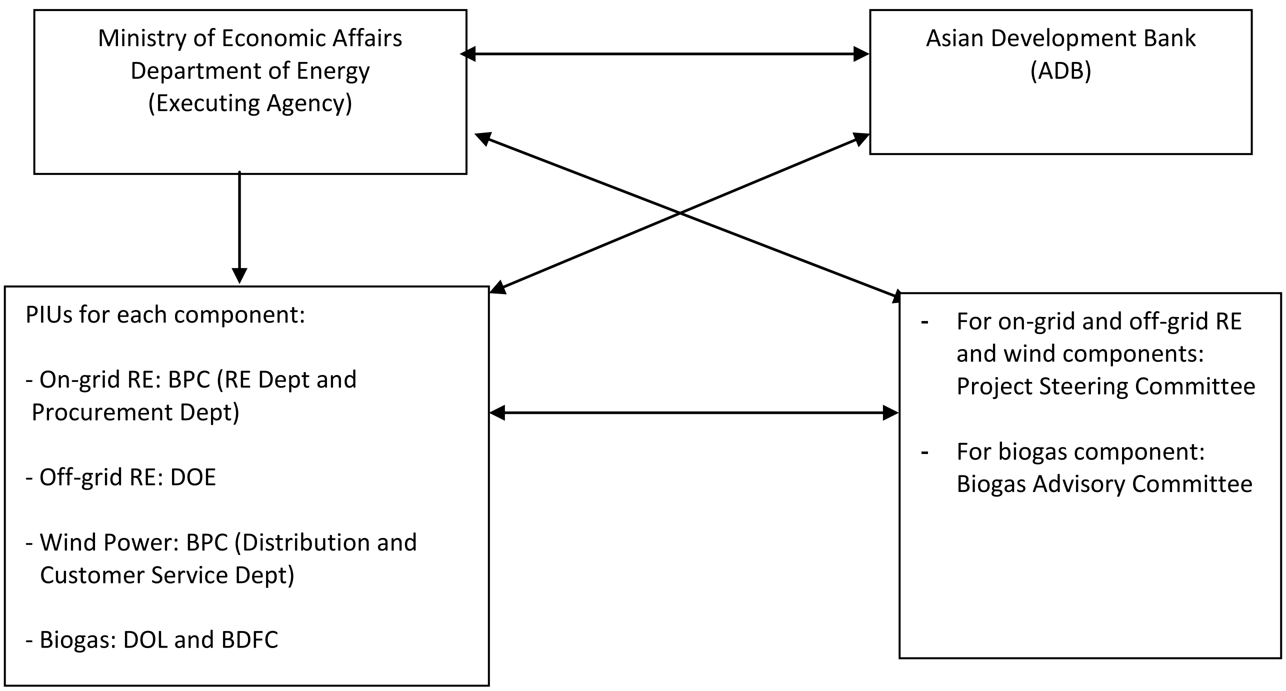
3.3 Project Organization Structure

5. The Department of Energy (DOE), Ministry of Economic Affairs will be the executing agency (EA) with overall responsibility for implementing the Project. The implementing agencies (IAs) are 1) the Bhutan Power Corporation (BPC) for the on-grid rural electrification and wind power components, 2) DOE for the off-grid rural electrification, and 3) the Department of Livestock (DOL), Ministry of Agriculture and the Bhutan Development Finance Corporation (BDFC) for the biogas component. Table C-2 summarizes the EA and IAs for each component and Figure C-1 shows the organizational structure of the Project. DOE and BPC have implemented the past four ADB-financed rural electrification projects and demonstrated good performance for project management. BDFC has also managed micro credits under the ADB program loans.

Table C-2: EA and IAs for Each Component		
Component	EA	IA
On-grid rural electrification	DOE	BPC
Off-grid rural electrification	DOE	DOE (BPC)*
Wind power generation	DOE	BPC
Biogas plants	DOE	DOL and BDFC

*Under the Project, DOE will own and procure goods, works, and services and BPC will support O&M.

Figure C-1: Project Organization Structure



4. COSTS AND FINANCING

4.1 Allocation and Withdrawal of Grant Proceeds

6. The total project cost is estimated at $24.91 million including contingencies. It is anticipated that ADB will grant $21.59 million, comprising: 1) $13.20 million for on-grid rural electrification, 2) $2.41 million for off-grid rural electrification, 3) $1.74 million for wind power generation, 4) $1.28 million for biogas plants, and 5) $2.95 million for overall contingencies. The government will cover the Project's counterpart fund for administration and overhead costs including staffing, taxes and duties, and part of the social and environmental mitigation costs.

ADB will finance the off-grid rural electrification's operations and maintenance works including spare parts and costs of village technicians contracted with BPC over the initial three years. After that, the government will ensure adequate budgetary allocations to cover the costs required for overall off-grid rural electrification's O&M from the energy royalty revenue account in a preferential manner.[27] Any taxes and duties will be financed by the government, not by ADB. The allocation of withdrawal of grant proceeds and detailed cost estimates are:

Table C-3: Allocation of Grant Proceeds

Package No.	Category	Allocation ($)	Withdrawal Percentage
Part A: On-grid rural electrification			
01	Works[1]	5,903,000	100% of total expenditure
02	Materials	7,300,600	100% of total expenditure
03	Unallocated	1,996,300	
	Total	15,199,900	
Part B: Off-grid solar rural electrification			
01	Works [1, 2]	595,000	100% of total expenditure
02	Equipment	1,720,000	100% of total expenditure
03	Consulting services	96,000	100% of total expenditure
04	Unallocated	473,000	
	Total	2,884,000	
Part C: Wind power generation			
01	Works[1]	186,000	100% of total expenditure
02	Equipment	1,340,000	100% of total expenditure
03	Consulting services	210,000	100% of total expenditure
04	Unallocated	314,000	
	Total	2,055,000	
Part D: Biogas plants			
01	Credit Line	663,000	100% of total expenditure
02	Equipment	12,000	100% of total expenditure
03	Consulting services[1, 3]	605,000	100% of total expenditure
04	Unallocated	473,000	
	Total	2,884,000	
	Grand Total	**21,590,000**	

[1]/ In Bhutan, no taxes and duties are imposed on ADB financed projects.
[2]/ Inclusive of costs of contractors for: village technicians ($0.576 million) under works of the off-grid solar rural electrification component and dealers of battery collections ($0.019 million) under works of the wind power generation component.
[3]/ Inclusive of provisional sum of training of $0.136 million.

[27] The three-year base costs for the off-grid RE operation and maintenance are estimated at $0.576 million. Any additional costs of BPC staff for backstop support will be reimbursed by the government.

4.2 Detailed Cost Estimates by Financier

Table C-4: Cost Estimates by Financier

	Total Cost	Financing Plan (US$ millions)					
	$ million	ADB [a]	Share %	RGoB/BPC	Share %	Others[b]	Share %
A. BASE COSTS							
I . INVESTMENT COSTS							
Civil Works	7.03	6.66	95%	0.12	2%	0.26	4%
Equipment	10.55	10.37	98%	0.18	2%	0.00	0%
Consultancy Services	1.24	0.98	79%	0.02	2%	0.24	19%
Enviornmental and Social Mitigation Costs	0.21	0.02	11%	0.18	89%	0.00	0%
TOTAL INVESTMENT COSTS	**19.03**	**18.03**	95%	**0.51**	3%	**0.50**	**3%**
II. RECURRENT COSTS							
Administrative and Overhead Cost	1.62	0.00	0%	1.62	100%	0.00	0%
Operations & Maintenance Outsourcing Service Costs	0.83	0.60	72%	0.23	28%	0.00	0%
Office Equipment and Supplies	0.03	0.01	43%	0.01	46%	0.00	11%
TOTAL RECURRENT COSTS	**2.48**	**0.61**	24%	**1.87**	75%	**0.00**	**0%**
TOTAL BASE COSTS	**21.51**	**18.64**	87%	**2.38**	11%	**0.50**	**2%**
B. CONTINGENCIES	**3.39**	**2.95**	87%	**0.37**	11%	**0.07**	**2%**
TOTAL PROJECT COST	**24.91**	**21.59**	87%	**2.75**	11%	**0.57**	**2%**

Notes

[a] Includes local transport and insurance costs, if any, to be financed by ADB.

[b] Others include costs of biogas users' upfront equity contributions ($0.30 million), and SNV contribution ($0.27 million) for capacity building support of the biogas program.

Source: Asian Development Bank

4.3 Detailed Cost Estimates by Component

Table C-5: Cost Estimates by Component

	Total Cost	On Grid RE	% of Cost Category	Off Grid RE (Solar)	% of Cost Category	Wind	% of Cost Category	Biogas	% of Cost Category
A. BASE COSTS									
I . INVESTMENT COSTS									
Civil Works	7.03	6.02	86%	0.00	0%	0.09	1%	0.92	13%
Equipment	10.55	7.45	71%	1.76	17%	1.35	13%	0.00	0%
Consultancy Services[a]	1.24	0.00	0%	0.12	9%	0.28	23%	0.84	68%
Enviornmental and Social Mitigation Costs	0.21	0.18	88%	0.00	0%	0.03	12%	0.00	0%
TOTAL INVESTMENT COSTS	**19.03**	**13.65**	72%	**1.87**	10%	**1.74**	9%	**1.76**	9%
II. RECURRENT COSTS									
Administrative and Overhead Cost	1.62	1.37	84%	0.0	0%	0.08	5%	0.15	9%
Operations & Maintenance Outsourcing Service Costs	0.83	0.00	0%	0.83	100%	0.00	0%	0.00	0%
Office Equipment and Supplies	0.03	0.00	0%	0.03	93%	0.00	0%	0.03	100%
TOTAL RECURRENT COSTS	**2.48**	**1.37**	55%	**0.85**	34%	**0.08**	3%	**0.18**	7%
TOTAL BASE COSTS	**21.51**	**15.02**	70%	**2.73**	13%	**1.82**	8%	**1.94**	9%
B. CONTINGENCIES	3.39	2.27	67%	0.53	16%	0.33	10%	0.26	8%
TOTAL PROJECT COST	**24.91**	**17.29**	69%	**3.26**	13%	**2.15**	9%	**2.20**	9%

Note:

[a] Consultancy services include training costs for the biogas component of $0.136 million.

Source: Asian Development Bank

4.4 Detailed Cost Estimates by Year

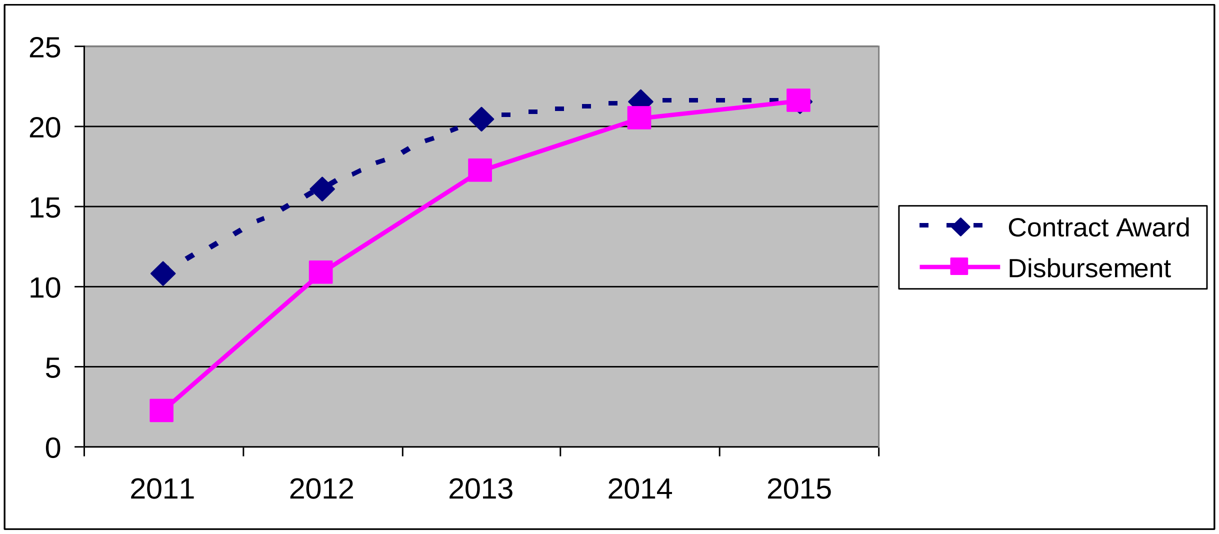
Table C-6: Cost Estimates by Year

	Total Cost	2011	2012	2013	2014	2015
A. BASE COSTS						
I . INVESTMENT COSTS						
Civil Works	7.03	0.79	2.77	2.87	0.30	0.30
Equipment	10.55	1.59	4.03	4.18	0.37	0.37
Consultancy Services	1.24	0.47	0.35	0.43	0.00	0.00
Enviornmental and Social Mitigation Costs	0.21	0.02	0.10	0.07	0.01	0.01
TOTAL INVESTMENT COSTS	**19.03**	**2.87**	**7.25**	**7.55**	**0.68**	**0.68**
II. RECURRENT COSTS						
Administrative and Overhead Cost	1.62	0.23	0.64	0.62	0.07	0.07
Operations & Maintenance Outsourcing Service Costs	0.83	0.20	0.27	0.36	0.00	0.00
Office Equipment and Supplies	0.03	0.01	0.01	0.01	0.00	0.00
TOTAL RECURRENT COSTS	**2.48**	**0.43**	**0.92**	**0.99**	**0.07**	**0.07**
TOTAL BASE COSTS	**21.51**	**3.30**	**8.17**	**8.54**	**0.75**	**0.75**
B. CONTINGENCIES	3.39	0.41	1.15	1.47	0.15	0.22
TOTAL PROJECT COST	**24.91**	**3.71**	**9.31**	**10.01**	**0.90**	**0.97**

Source: Asian Development Bank

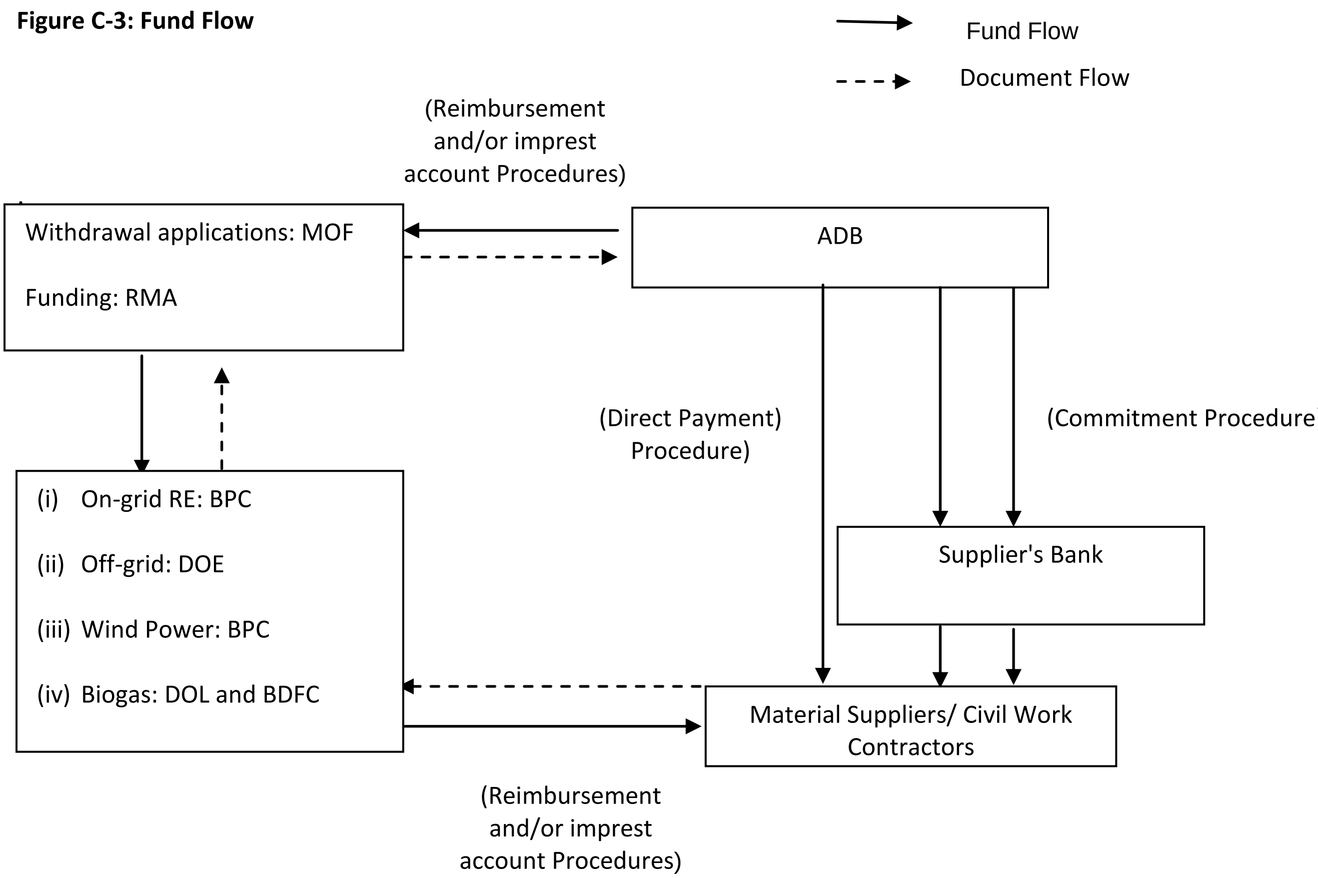
4.5 Contract and Disbursement S Curve

Figure C-2: Contract and Disbursement Cost Curve



4.6 Fund Flow Diagram

Figure C-3: Fund Flow



ADB = Asian Development Bank, BDFC = Bhutan Development Finance Corporation, DOE = Department of Energy, DOL = Department of Livestock, BPC = Bhutan Power Corporation, MOF = Ministry of Finance

5. FINANCIAL MANAGEMENT

5.1 Financial Management Assessment

7. The financial management of the EA and IAs is satisfactory. These agencies are audited on a regular basis and no specific issues have been raised by the auditors. The financial management assessments of EA and IAs were carried out using the Financial Management Assessment Questionnaire provided by the ADB. The Questionnaire covers a broad range of issues, including its legal status and statutory reporting requirements, fund flow arrangements, staffing, accounting policies and procedures, budgeting system, accounting and management controls and internal and external auditing.

The Department of Energy (DOE), Ministry of Economic Affairs and the Department of Livestock (DOL), Ministry of Agriculture

8. The DOE, a department within the Ministry of Economic Affairs, will execute the project. The department currently has a staff of 226. The DOE has experience with the ADB, executing the previous rural electrification projects. The DOL will implement the biogas component. DOE and DOL use the standardized budget and accounting software system used by government departments to produce financial statements on a cash accounting basis. The system produces monthly expenditure statements against each budget head, receipts and payments summary and bank reconciliation statement, which are part of standard reporting to the Ministry of Finance.

Bhutan Power Corporation Limited (BPC)

9. The BPC is a government-owned corporation incorporated on 1 July 2002. Its mandate covers the construction and operation of electrical networks, sale of electricity within the country, and wheeling of electricity for export. The BPC had a total staff of 1,755 at the end of 2009 and operates through 19 electricity service divisions (ESD) throughout the country. The BPC is organized into the departments for transmission, rural electrification, development and construction, procurement services, finance, human resources and central maintenance and training. The Finance Department is headed by a general manager, and reporting to him are officers responsible for accounting, budgeting, management information and asset management. In addition, there are accounting officers at the ESDs that also report to the finance manager. Financial statements are produced on an Oracle database up to the stage of trial balance and thereafter using Microsoft Excel spreadsheets. The BPC is currently implementing a SAP system for an integrated enterprise resources planning. The BPC has a

four-member Internal Audit Department and is also audited annually by a private external auditor from India. It is also audited by the Royal Audit Authority (RMA).

Bhutan Development Finance Corporation Limited (BDFC)

10. The BDFC was formed on 31 January 1988 as a financial institution to cater to the needs of the micro, small and medium enterprises with a special focus on agricultural development. The BDFC was registered as a non-bank financial institution with the RMA until March 2010. On 2 March 2010, the RMA issued BDFC a license enabling it to solicit deposits from corporate entities and individuals and is now a specialized deposit taking bank. The BDFC has its head office in Thimphu, three regional offices in the western, central and eastern regions, and 24 branch offices. It plans to open its 25th branch in Dorokha during 2010. It also operates a mobile banking facility. This extensive outreach enables the BDFC to service the majority of rural communities. At the end of 2009, the BDFC had 19,923 active clients, which is about one fifth of the rural households in the country. At the end of 2009, the BDFC had 221 employees on its payroll, 95 at the head office and 137 at the branches, and has separate departments for credit, finance, administration and human resources. It recently established a separate division for credit risk and portfolio quality. The Accounting Division at the head office has seven staff. Financial statements are produced by the system itself which is a purpose-built software package. The BDFC has a nine-member Internal Audit Department and is also audited annually by a private external auditor from India. It is also audited by RMA annually. Furthermore, it is subject to the Prudential Guidelines issued by the RMA. The BDFC is currently the IA for the ADB-funded Micro, Small and Medium Sized Enterprise Development Program and has also received technical assistance from ADB for the development of a five-year business plan and strategy and capacity development.

5.2 Disbursement

11. The grant proceeds will be disbursed in accordance with ADB's *Loan Disbursement Handbook* (2007, as amended from time to time),[28] and detailed arrangements agreed upon between the government and ADB.

12. Pursuant to ADB's *Safeguard Policy Statement* (2009) (SPS),[29] ADB funds may not be applied to the activities described on the ADB Prohibited Investment Activities List set forth at Appendix 5 of the SPS.

13. Disbursement of grant funds under the Project will be mainly for the supply of materials and construction of civil works, through ADB's disbursement procedures including direct payment, commitment, and reimbursement. The biogas component will follow the imprest account procedures.

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[28] Available at: http://www.adb.org/Documents/Handbooks/Loan_Disbursement/loan-disbursement-final.pdf

[29] Available at: http://www.adb.org/Documents/Policies/Safeguards/Safeguard-Policy-Statement-June2009.pdf

14. For the biogas component, separate imprest accounts and statements of expenditures (SOE) will be established and maintained by the RMA and BDFC. The government will establish, or cause to be established, immediately after the Effective Date, a first-generation imprest account at the Royal Monetary Authority, and a second-generation imprest account (SGIA) for the BDFC. The maximum ceiling of the imprest accounts will not at any time exceed the estimated ADB-financed expenditures to be paid from the imprest account for the next 6 months or 10% of the grant amount, whichever is lower. The maximum ceiling of each imprest account will be equivalent to 6 months of estimated expenditures to be funded from each SGIA or $100,000, whichever is lower. The request for initial advance to the imprest account will be accompanied by an Estimate of Expenditure Sheet[30] setting out the estimated expenditures for the first 6 months of project implementation, and submission of evidence satisfactory to ADB that the imprest account has been duly opened. For every liquidation and replenishment request of the imprest account, the borrower will furnish to ADB 1) statement of account (bank statement) where the imprest account is maintained, and 2) the imprest account reconciliation statement (IARS) reconciling the above mentioned bank statement against the BDFC's records.[31] The SOE records will be maintained and made readily available for review by ADB's disbursement and review mission or upon ADB's request for submission of supporting documents on a sampling basis, and for independent audit.[32] The BDFC will ensure that their investments are in compliance with applicable national laws and regulations and will apply the prohibited investment activities list to subprojects financed by ADB.

15. Before the submission of the first withdrawal application, the government should submit to ADB sufficient evidence of the authority of the person(s) who will sign the withdrawal applications on behalf of the government, together with the authenticated specimen signatures of each authorized person. Each of the IAs will be responsible for 1) preparing disbursement projections for each year, 2) requesting budgetary allocations for counterpart funds, 3) collecting supporting documents, and 4) preparing and sending withdrawal applications to ADB. Withdrawal applications and supporting documents will demonstrate, among other things, that the goods, and/or services were produced in or from ADB members, and are eligible for ADB financing.

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[30] Available in Appendix 29 of the *Loan Disbursement Handbook.*

[31] Follow the format provided in Appendix 30 of the *Loan Disbursement Handbook.*

[32] Checklist for SOE procedures and formats are available at:
http://www.adb.org/documents/handbooks/loan_disbursement/chap-09.pdf
http://www.adb.org/documents/handbooks/loan_disbursement/SOE-Contracts-100-Below.xls
http://www.adb.org/documents/handbooks/loan_disbursement/SOE-Contracts-Over-100.xls
http://www.adb.org/documents/handbooks/loan_disbursement/SOE-Operating-Costs.xls
http://www.adb.org/documents/handbooks/loan_disbursement/SOE-Free-Format.xls

16. Government counterpart funds will mainly be used for overhead and administrative costs including staffing, taxes and duties[33] and part of the social and environmental mitigation costs.

5.3 Accounting

17. Each of the IAs will maintain separate project accounts and records by funding source for all expenditures incurred on each of the Project's four components. Project accounts will follow international accounting principles and practices.

5.4 Auditing

18. Each of the IAs will cause the detailed consolidated project accounts to be audited by an auditor acceptable to ADB in accordance with international standards on auditing and the government's audit regulations. The audited accounts will be submitted in the English language to ADB within 6 months of the end of the fiscal year by the executing agency. The annual audit report will include a separate audit option on the use of the imprest accounts and SOE procedures. The government of Bhutan and each of IAs have been made aware of ADB's policy on delayed submission, and the requirements for satisfactory and acceptable quality of the audited accounts. ADB reserves the right to verify the project's financial accounts to confirm that the share of ADB's financing is used in accordance with ADB's policies and procedures. The BPC will also submit its audited financial statements for each year within 6 months of the end of each fiscal year.

6. PROCUREMENT AND CONSULTING SERVICES

6.1 Advance Contracting and Retroactive Financing

19. All advance contracting will be undertaken in conformity with ADB's *Procurement Guidelines* (2010, as amended from time to time)[34] and ADB's *Guidelines on the Use of Consultants* (2010, as amended from time to time).[35] The issuance of invitations to bid and express interest under advance contracting will be subject to ADB approval. The borrower, the EA, and the IAs have been advised that approval of advance contracting does not commit ADB to finance the Project.

[33] One of the examples is tax deducted at source (TDS).
[34] Available at: http://www.adb.org/Documents/Guidelines/Procurement/Guidelines-Procurement.pdf
[35] Available at: http://www.adb.org/Documents/Guidelines/Consulting/Guidelines-Consultants.pdf

20. In order to expedite the Project's implementation, the government has requested approval for advance contracting actions for the procurement of goods and works and selection of consulting services. The steps to be concluded in advance include 1) preparation of bidding documents, 3) bidding, 4) bid evaluation for the procurement of both goods and civil work portions, and 4) recruitment of consultants. The government also requested retroactive financing within the proposed Project financing scope.

6.2 Procurement of Goods, Works, and Consulting Services

21. All procurement of goods and works will be undertaken in accordance with ADB's *Procurement Guideline.* International competitive bidding (ICB) procedures will be used for the procurement of materials, equipment, supply and installation contracts valued at $500,000 or higher. National competitive bidding (NCB) will be used for civil works worth less than $1,000,000 and supply contracts worth less than $500,000. Before the start of any procurement, ADB and the government will review the public procurement laws of the government to ensure consistency with ADB's *Procurement Guideline.*

22. An 18-month procurement plan indicating threshold and review procedures, goods, works, and consulting service contract packages and national competitive bidding guidelines is discussed in Section 6.3.

23. All consultants will be recruited according to ADB's *Guidelines on the Use of Consultants*.[36] The terms of reference for all consulting services are detailed in Section 6.4.

6.3 Procurement Plan

Basic Data

Project Name: Rural Renewable Energy Development Project	
Country: Bhutan	**Executing Agency**: Depart of Energy, Ministry of Economic Affairs
Grant Amount: $21.59 million	**Grant Number:** (To be determined)
Date of First Procurement Plan: May 2010	**Date of this Procurement Plan**: September 2010

Process Thresholds, Review and 18-Month Procurement Plan

24. **Project Procurement Thresholds.** Except as the ADB may otherwise agree, the following process thresholds shall apply to the procurement of goods and works.

[36] Checklists for actions required to contract consultants by method available in e-Handbook on Project Implementation at: http://www.adb.org/documents/handbooks/project-implementation/

Table C-7: Procurement of Goods and Works	
Method	**Threshold**
International Competitive Bidding for Goods	At least $500,000
National Competitive Bidding (NCB) for Works	Between $1,000,000 and $100,000
National Competitive Bidding for Goods[1]	Between $500,000 and $100,000
Shopping for Works	Below $100,000
Shopping for Goods	Below $100,000

25. **ADB Prior or Post Review.** Except as ADB may otherwise agree, the following prior or post-review requirements apply to the various procurement and consultant recruitment methods used for the Project.

Table C-8: Procurement Requirements		
Procurement Method	**Prior or Post**	**Comments**
Procurement of Goods and Works		
ICB Goods	Prior	
NCB Works	Prior	
NCB Goods	Prior	
Shopping for Works	Prior	
Shopping for Goods	Prior	
Recruitment of Consulting Firms		
Single Source Selection (SSS)	Prior	SSS was approved on 2 Sep 2010.
Recruitment of Individual Consultants		
Individual Consultants	Prior	

26. **Goods and Works Contracts Estimated to Cost More than $1 Million.** Table C-9 lists goods and works contracts for which procurement activity is either ongoing or expected to commence within the next 18 months.

Table C-9: Good and Works Contracts					
General Description	**Contract Value ($ million)**	**Procurement Method**	**Prequalification of Bidders** (y/n)	**Advertisement Date** (quarter/year)	**Comments**
On-grid RE					
1. Telescopic Poles	2.37	ICB (Goods)	N	4th Quarter 2010	
2. Conductors	1.03	ICB (Goods)			
Off-grid solar RE					
3. Turnkey solar home system package	1.14	ICB (Supply)	N	1st Quarter 2011	
Wind power generation					
4. Turnkey of supply & installation of Wind	1.345	ICB (Supply)	N	4th Quarter 2011	

Table C-9: Good and Works Contracts
Turbines
RE = rural electrification, ICB = international competitive bidding.

27. **Consulting Services Contracts Estimated to Cost More than $100,000.** Table C-10 lists consulting services contracts for which procurement activity is either ongoing or expected to commence within the next 18 months.

Table C-10: Anticipated Procurements

General Description	Contract Value ($ million)	Recruitment Method[1]	Advertisement Date (quarter/year)	International or National Assignment	Comments
Wind power generation					
1. Wind Power Design & Implementation	0.210	ICS	1st Quarter 2011	International (1)	
Biogas plants					
2. Biogas Design & Implementation	0.61	SSS	4th Quarter 2010 (Letter of Invitation)	International (1), National (1)	SSS was approved on 2 Sep 2010.[a]

[a] SNV was selected as a consultant through a single source selection because 1) it has unique expertise and qualifications for creating the biogas market and 2) this Project is a continuation of its previous work. SNV will also finance part of consulting services cost for implementation support and capacity development. The amount for the consultancy services includes training costs for the biogas component of $0.176 million as a provisional sum of ADB finance.

28. **Goods and Works Contracts Estimated to Cost Less than $1 Million and Consulting Services Contracts Less than $100,000.** Table C-11 groups smaller-value goods, works and consulting services contracts for which procurement activity is either ongoing or expected to commence within the next 18 months.

Table C-11: Good and Works Contracts				
General Description	Value of Contracts (cumulative)	Number of Contracts	Procurement / Recruitment Method[1]	Comments
A. On-Grid Rural Electrification	**($ million)**			
1. Pole fitting & accessories	0.42	One	ICB(Goods)	
2. Insulators)	0.52	One	ICB(Goods)	
3. Cables	0.40	One	ICB(Goods)	
4. Earthing equipment	0.26	One	ICB(Goods)	
5. Transformers	0.73	One	ICB(Goods)	
6. Conductor/cable fittings & accessories	0.12	One	ICB(Goods)	
7. Switching equipment & accessories	0.86	One	ICB(Goods)	
8. Energy meter	0.02	One	ICB(Goods)	
9. Shield wire materials	0.72	One	ICB(Goods)	
10. Transportation and erection works (numerous sub-packages)	6.02	Several	NCB(Works)	
B. Off-Grid Solar Rural Electrification				
11. Supply of solar spare parts	0.62	Several	Shopping(Goods)	
12. OM outsourcing (village technicians)	0.58	Several	Shopping(Works)	
13. Used battery collection	0.02	Several	Shopping(Works)	
14. Consulting services for training & operation	0.10	One	Individual	
C. Wind Power Generation				
15. Access road	0.09	One	Shopping(Works)	
16. Installation of noise barriers	0.02	One	Shopping(Works)	
17. Supply and installation of wind Masts	0.07	One	Shopping(Works)	
D. Biogas Plants				
18. Office equipment	0.01	One	Shopping(Goods)	

Indicative List of Packages Required Under the Project

29. All procurements (goods, works, and consulting services) will be implemented within the next 18 months; therefore, they are all listed in the above tables in Para. 26 to 28.

National Competitive Bidding

30. **General.** The procedures to be followed for national competitive bidding shall be the open tendering/bidding method set forth in the *Procurement Rules and Regulations 2009* issued by the Minister of Finance of the Royal Government of Bhutan with the clarifications

and modifications described in the following paragraphs required for compliance with the provisions of the ADB *Procurement Guidelines*.

31. **Registration.** Bidding shall not be restricted to pre-registered firms under the national registration system of the Construction Development Board (CDB), and such registration shall not be a condition for the submission of bids in the bidding process.

32. Where registration is required prior to award of contract, bidders: 1) shall be allowed a reasonable time to complete the registration process and 2) shall not be denied registration for reasons unrelated to their capability and resources to successfully perform the contract, which shall be verified through post-qualification.

33. **Prequalification.** Post-qualification shall be used unless prequalification is explicitly provided for in the loan agreement/procurement plan. Irrespective of the procedure applied (whether prequalification or post-qualification), no domestic or foreign contractor shall be precluded from participation.

34. If prequalification is undertaken, the prequalification criteria should include "Eligibility Requirements," "Financial Situation," "Pending Litigation," and "Experience." Technical Capacity (personnel and equipment) should not be part of the prequalification criteria.

35. A minimum period of 28 days shall be allowed for the preparation and submission of prequalification applications. The 28-day period is to be counted from either 1) the date of publication of the prequalification invitation in a local newspaper or website, or 2) the commencement date for the issue of the prequalification documents to interested parties, whichever of the two dates is the later, up to the date set for the deadline for submission of the prequalification applications.

36. **Procurement Process.** One envelope process shall be used unless a two-stage process is explicitly provided for in the loan agreement/procurement plan.

37. **Advertising.** Bidding of NCB contracts estimated at $500,000 or more for goods and related services or $1,000,000 or more for civil works shall be advertised on ADB's website via the posting of the Procurement Plan.

38. **Bidding Documents.** Procuring entities shall use standard bidding documents acceptable to ADB for the procurement of goods, works and related services, based ideally on the standard bidding documents issued by ADB.

39. **Packaging.** Slicing or splitting of contracts within a package shall not be used to change the contract sizes and the corresponding methods of procurement indicated in the loan agreement/procurement plan.

40. **Bid Security and Performance Security.** Where required, bid security (earnest money),

retention money (or security deposit) and performance security (or performance guarantee) shall be in the form of a demand draft, certified check, letter of credit, or bank guarantee from a reputable bank.

41. The terms and conditions of bid security as well as retention money and performance security shall be clearly specified in the forms provided and/or conditions of contract in terms of periods of validity and grounds for forfeiture, or release of the bank guarantees, or refund of the cash security deposits.

43. **Preferences.** No preference of any kind shall be given to domestic bidders or for domestically manufactured goods.

44. Foreign suppliers and contractors from ADB member countries shall be allowed to bid, without registration, licensing, and other government authorizations, leaving compliance with these requirements for after award and before signing of contract.

45. **Rejection of All Bids and Re-bidding.** Bids shall not be rejected and new bids solicited without the ADB's prior concurrence.

46. **Low Bids and Unbalanced Bids.** Bids shall not be rejected solely because the bid price is 1) lower by a certain percentage of the contract cost estimate, or 2) seriously unbalanced or front loaded. Instead of rejecting the bids, the bidder whose bid is determined to be the lowest evaluated substantially responsive bid may be required by the Executing Agency/Implementing Agency (EA/IA) to provide a higher performance security to a level sufficient to protect the EA/IA against financial loss in the event of default of the successful bidder under the Contract.

47. **Participation by Government-Owned Enterprises.** Government-owned enterprises in Bhutan shall be eligible to participate only if they can establish that they are legally and financially autonomous, operate under commercial law, and are not a dependent agency of the procuring entity, or the Project Executing Agency or Implementing Agency.

48. **Member Country Restrictions.** Bidders must be nationals of member countries of ADB, and offered goods, works and services must be produced in and supplied from member countries of ADB.

49. **Exclusion of Bidders.** Exclusion of bidders for reasons cited in section 2.14 of Bhutan Procurement Rules and Regulations 2009, including inclusion on national sanctions lists, may be applied only with the prior approval of ADB. Rejection of bids on account of "past poor performance" of bidders shall also be subject to ADB's prior approval.

50. **Disclosure of Decision on Contract Awards.** At the same time that notification on award of contract is given to the successful bidder, the results of bid evaluation shall be published in a local newspaper, or a well-known freely accessible website identifying the bid and lot numbers

and providing information on the 1) name of each bidder who submitted a bid, 2) bid prices as read out at bid opening, 3) name of bidders whose bids were rejected and the reasons for their rejection, and 4) name of the winning bidder, and the price it offered, as well as duration and summary scope of the contract awarded. The executing agency/implementing agency/contracting authority shall respond in writing to unsuccessful bidders who seek explanations on the grounds on which their bids are not selected.

6.4 Consultant's Terms of Reference

51. The consultant will be recruited by the DOE/DOL according to ADB's *Guidelines on the Use of Consultants* (2010, as amended from time to time).

Off-Grid Rural Electrification's Operation and Maintenance (International, 3 person-months)

52. An international consultant with expertise in off-grid solar home system (SHS) operation and maintenance and project management will be recruited. The consultant will assist the Project Implementation Unit (PIU) in the Department of Energy in developing and implementing SHS O&M services to ensure all the installed SHS sets will function properly. The consultant's outline terms of reference will include, but not necessarily be limited to, the following tasks:

(i) Assist the PIU in developing and implementing the off-grid SHS O&M service program for all installed SHS sets in Bhutan.
(ii) Assist the PIU in identifying all installed SHS sets in off-grid villages based on the database of SHS sets maintained by the DOE, and in developing the plan and schedule for O&M services to be provided by BPC's village technicians.
(iii) Finalize the SHS O&M service forms for recording the time spent, the services provided, the parts replaced, the pending repair and service items, needs for new spare parts and other service data to be used by BPC's village technicians.
(iv) Prepare accounting procedures and forms for the BPC to prepare summary reports on the O&M services provided, the parts replaced, the needs for new spare parts, and the expenses incurred to DOE, and claim reimbursements from DOE.
(v) Develop cost-effective procedures and guidelines for verifying the O&M services and parts replacements claimed by village technicians, and monitoring the customer satisfaction of the O&M services provided.
(vi) Assist the PIU in forecasting needs for new spare parts and developing spare parts procurement plans and schedules for the PIU to procure spare parts for delivery to BPC's customer service centers to enable village technicians to perform parts replacements in a timely manner.
(vii) Assist the PIU in developing a plan for collecting used batteries from BPC's Customer Service Centers and transporting the collected batteries to Phuentsholing to be

transferred to licensed battery recyclers in India for recycling according to India's laws, assist the PIU in complying with the Safeguard Requirements.

(viii) Assist the PIU in analyzing the spare parts replacement data to determine the reliability of the SHS components and make recommendations to improve SHS reliability for future installations.

(ix) Assist the PIU in preparing management information reports and other project progress reports required by the government and ADB.

Wind Power Generation (International, 7 person-months)

53. An international consultant with expertise in wind power will be recruited. The consultant will assist the DOE and the Project Implementation Unit (PIU) in wind resource assessment, wind turbines design and specification, tendering, and construction technical support. The consultant's outline terms of reference will include, but not necessarily be limited to, the following tasks:

(i) Assist in identifying and installing wind masts at three additional sites.

(ii) Analyze the wind data collected at site, assess the wind resource, estimate wind energy production and profiles based on the actual measurement of wind data, and confirm the economic viability.

(iii) Prepare wind farm layout general arrangements.

(iv) Design the access and internal roads and hard standing areas, and electrical connections from the wind turbines to the existing distribution grid.

(v) Prepare design specification documents for the wind turbines, erection, installation, testing and commissioning.

(vi) Prepare design specification documents for the access roads, hard standing areas and wind turbine foundations.

(vii) Prepare design specifications for the electrical connection cabling and pad mount substations.

(viii) Assist in the preparation of bid documents, especially the design specifications, bill of quantities, construction schedule, and qualification and evaluation criteria, and cost estimate of the package.

(ix) Prepare a warranty operation and maintenance agreement between the Implementing Agency and the wind turbine supplier.

(x) Assist in bid evaluation and contract negotiations.

(xi) Work with the wind turbine supplier to finalize the detailed site design of the wind turbines and other project components.

(xii) Provide technical support during manufacturing and delivery of wind turbines, construction of access roads and foundations, electrical connections, transportation and erection, and test and commissioning.

(xiii) Assist in the preparation of project review reports during the project implementation and with the project completion report.

(xiv) Provide on-the-job training to PIU staff during project implementation.

Biogas Plants

54. An international biogas expert and a national biogas specialist will be required to assist the Project Implementation Unit (PIU) in project planning, implementation, capacity building, training, promotion, marketing, quality control, monitoring and evaluation. These consultants will work full time with the PIU for three years, and liaison with private masons, appliance dealers and energy service providers. They will also conduct training programs and procure office equipment for the PIU. The consultants' outline terms of reference will include, but not necessarily be limited to, the following tasks.

55. **International Biogas Advisor (international, 36 person-months).** The consultant will perform the following tasks:

(i) Provide day-to-day support and advice to the Project Implementing Unit (PIU) to implement the biogas pilot project, and advise the Biogas Advisory Committee in Bhutan.
(ii) Establish technical designs and standards for biogas plants and assist in inspections of biogas installations.
(iii) Check and approve materials and construction plans for the biogas installations.
(iv) Prepare training materials on biogas plant design, construction, operation and maintenance, and supervise actual training of private masons, biogas appliance dealers, operation and maintenance service providers as well as the PIU staff and Department of Livestock's (DOL) extension officers at the district and block levels. These training materials will include procedures to identify masons with sufficient competence to be issued a certificate of competence on completing the training.
(v) Develop the biogas promotion, information and marketing materials, and coordinate the marketing activities with the PIU and DOL extension officers.
(vi) Carry out outreach activities and processes that can add value to the biogas project and enhance the benefits of the biogas plants to the participating farmers. Identify opportunities to coordinate the biogas project with other programs where possible to maximize the market penetration of the biogas plants.
(vii) Develop the procedures and templates for the participating farmers, private masons and others to submit application for subsidy, and referring to the Bhutan Development Finance Corporation (BDFC) for application of biogas credits.
(viii) Develop procedures and templates for the PIU to authorize the BDFC to release subsidies to participating farmers or plant construction contractors.
(ix) Facilitate the evaluation and impact assessment of the project's marketing, subsidy and micro-credit designs and processes, and develop survey instruments for assessing impacts; this may involve the coordination of inputs from environmental, livestock and social development experts.
(x) Monitor and evaluate the project progress and achievements in each phase, identify any implementation barriers encountered, and develop plans to remedy and improve implementation in the subsequent phases.

(xi) Advise the PIU and the Biogas Advisory Committee on all matters related to biogas development and implementation in Bhutan.
(xii) Give direction for the implementation of the pilot project activities by providing on-the-job support, coaching, technical backstopping and guidance to the PIU staff, DOL extension officers in the field, participating masons and private parts dealers and repair service providers.
(xiii) Transfer relevant knowledge gained through the ongoing biogas programs in other Asian countries through maintaining an effective network.
(xiv) Assist the PIU in preparing the project achievement reports, progress reports, project monitoring and evaluation reports, and other documents required by the government and ADB.

56. **National Biogas Specialist (national, 36 person-months).** The consultant will conduct the following tasks:

(i) Take responsibility for maintaining quality plant construction and after-sales services by plant contractors.
(ii) Visit plant construction sites regularly. All plants constructed in the assigned district need to be visited for quality control: once at the 50% stage and once on completion.
(iii) Complete quality control forms correctly and accurately and send the completed forms to the PIU for coordinating with the BDFC on processing subsidy and credit application evaluation.
(iv) Take immediate action if plants are not constructed as per approved standards.
(v) Address any technical problems encountered by users and report it to the International Biogas Advisor for developing solutions.
(vi) Provide feedback and advice regularly to plant constructors and masons on technical improvement.
(vii) Follow exactly the instruction and process of quality control and reporting system approved by the PIU office.
(viii) Conduct masons/supervisors training in the local areas. This involves:
   (a) Coordinating training programs for multiple masons at one time, including both classroom and field training on construction techniques.
   (b) Training on materials selection
   (c) Construction plans, scheduling, and procedures
   (d) Construction quality control
   (e) Identify masons who are suitable for certification as qualified contractors under the program, and select masons who require additional training and capacity building before they can be certified.

7. SAFEGUARDS

57. The EA and IAs will ensure the implementation of the respective environmental management plans (EMP) of all four components. They will also ensure that the EMPs prepared comply with local environmental laws and regulations promulgated by the National Environment Commission (NEC). Should there be any change in the configurations of any project components during implementation, the EMPs will be revised accordingly. The EA and the IAs will assist in promoting environmentally responsible implementation of the contracts. The mitigation measures will be incorporated into the contractor's contract document. The IA will monitor, audit, and report to ADB twice a year on the implementation of the EMP for each Project component, if applicable.[37] Summary appraisal reports will be submitted to ADB subsequent to the EA's approval.

58. The contractor/subcontractor shall prepare and submit quarterly progress reports in conformance with the IAs and shall indicate when, how and at what cost the contractors plan to satisfy the requirements as per detailed specifications. For each component, these programs shall detail the resources to be provided or utilized and any related subcontracting proposed.

59. No indigenous peoples have been identified as beneficiaries or as adversely affected groups under any of the proposed Project components. In the same manner, no involuntary resettlement or relocation will be required. The Project is not expected to have adverse impacts on livelihoods. However, where livelihoods are considered to have suffered as a result of the Project (due to land acquisition or other unforeseen matters), EA/IAs will be responsible for responding in an appropriate and timely manner, bearing in mind the livelihood restoration needs and requirements of those affected, in compliance with ADB Safeguard Policy.

60. The wind power component will require some land acquisition. This has been adequately addressed in the Resettlement Plan. The affected persons will be provided substitute land as per their preference. The compensation for standing crops, if any at the time of the road construction, will be provided. Payment for land preparation at the substituted land will be provided. In-depth discussions with the affected person have been carried out and they have consented to give their land. The Chukha dzongkhag Administration and DOE/BPC will be in charge of the resettlement exercise and they have the capacity to handle the exercise.

61. Project implementation will likely pose impacts of a temporary, reversible and insignificant nature on peoples living in the direct area of influence of construction works. IAs and their contractors will be responsible for managing and addressing community, health and safety, and labor issues in an appropriate and timely manner, in line with national laws and ADB grant requirements. In addition, a "chance find procedures" protocol will be implemented to manage the institutional arrangements required between the implementing agency and the

[37] Where all subprojects will result in insignificant environmental impacts, financial intermediaries are not required to adopt an environmental management system or environmental assessment.

government in the case archeological, cultural or religious artifacts are encountered during any clearing or excavation works.

8. GENDER AND SOCIAL ANALYSIS

62. The Project will prove beneficial for poverty reduction and income generation. As rural areas usually fall behind in both access to social services and income opportunities, the grid expansion along with the development of other infrastructure such as roads and public utilities, is expected to boost the local economy and provide additional health, educational and recreational-related benefits. The BPC will assign 120 village technicians (including 40% female) responsible for performing on-grid and off-grid rural electrification operation and maintenance services.

9. PERFORMANCE MONITORING, EVALUATION, REPORTING AND COMMUNICATION

9.1 Project Design and Monitoring Framework

Table C-12: Project Design and Monitoring Framework

Design Summary	Performance Targets/Indicators	Data Sources/Reporting Mechanisms	Assumptions and Risks
Impact Sustained inclusive economic growth through reliable and affordable clean energy services	Increase in the energy sector's share of GDP from 25% to 40% (2017) Reduced proportion of people living below the national poverty line from 23.2% to 20% by 2015 Diversification of energy supply sources through renewable energy including solar, wind, and biogas up to 70 MW equivalent by 2020 Maintained proportion of forestry area (72.5%) in the country	Government statistical and census reports Government five-year plans UNDP Bhutan Annual Report (for Millennium Development Goals) Economic reports of Government, ADB, IMF, and World Bank	**Assumptions** • Government's high policy priority and firm investment to rural development and poverty reduction • Stable macroeconomic growth in South Asia • Renewable energy technology improvement and capital cost decrease • Issuance and execution of Renewable Energy Policy • Government's policy for forestry conservation **Risks** • Exogenous economic and political shocks

Table C-12: Project Design and Monitoring Framework			
Design Summary	**Performance Targets/Indicators**	**Data Sources/Reporting Mechanisms**	**Assumptions and Risks**
	Reduction of domestic use of fuelwood by 30% from the 2005 consumption level by 2020		
Outcome Expanded coverage and mix of clean energy supply in a sustainable manner	Increase in access to electricity by rural and urban households, achieving a cumulative national electrification ratio from 54% (2008) to 100% (2013) of all households Access to clean renewable energy sources to all off-grid rural households by 2013 BPC's financial health including sufficient debt service coverage (minimum 1.2) and net profit generation Deployment of over 120 rural village technicians including 40% female by 2013 Reduction of emission gas equivalent to CO_2 by 25,000 tons per annum[1]	Project completion report Audit financial accounts and reports National statistics Government's fiscal statements Economic reports of Government, ADB, IMF, and World Bank NEC's monitoring report	**Assumptions** • Government's commitment to promote development for rural electrification and renewable energy development • Government's commitment and framework to ensure BPC's cost recovery • Timely implementation of ongoing projects for rural electrification • ADA's and JICA's parallel financing and continuous support for rural electrification **Risks** • Natural disaster
Outputs 1. On-grid rural electrification sourced from hydropower, and its related skills training and livelihood improvement activities[2] 2. Off-grid rural electrification sourced from solar power, and its related skill training and livelihood improvement	Provision of reliable power supply sourced from hydropower through grid extensions to 5,075 households by 2013 [with target: 30% households headed by women] Installation of solar home systems for 1,896 new households by 2013 [with target: 30% households headed by women]	ADB review missions' aide memoires Quarterly project progress reports Project completion report Withdrawal applications, and disbursement and contract award records Audit of financial accounts	**Assumptions** • Government's commitment to carry out the Project • Timely mobilization of the Government's counterpart funds • High quality of consultancy services for implementation support • Accessibility to the development sites • ADA's and JICA's parallel finance in a timely manner • SNV's support for biogas capacity building

Table C-12: Project Design and Monitoring Framework			
Design Summary	**Performance Targets/Indicators**	**Data Sources/Reporting Mechanisms**	**Assumptions and Risks**
activities[2] 3. Wind power generation plants 4. Domestic biogas plants	Rehabilitation of 2,500 existing solar home systems by 2014 Training of 120 village technicians including 40% female for operation and maintenance for on-grid and off grid rural electrification by 2013[2] Livelihood improvement programs to 200 women in the project area by 2014[2] Distribution of 4,500 user manuals for safety and operation awareness of solar home systems[2] Construction of wind power mills with a capacity of 360 kW on a pilot basis and installation of three wind masts by 2014 Construction of 1,600 domestic biogas plants on a pilot basis by 2014	and reports Government's fiscal statement	• Training program for village technicians and livelihood improvement activities to be provided from the Improving Gender Inclusive Access to Clean and Renewable Energy in Bhutan, Nepal, and Sri Lanka **Risks** • Unexpected cost increases in commodities and raw materials beyond contingencies • Construction delays due to slow procurement, design changes, or natural disaster • Lack of sufficient and appropriate human resources and expertise
Activities with Milestones 1. Finalization of technical specifications and cost estimates by Aug 2010 2. Issuance of environmental clearances by June 2010 3. Commencement of advance procurement by the fourth quarter of 2010 4. Contract award by the first quarter of 2011 5. Consultant hiring for the solar, wind and biogas components by the first quarter of 2011 6. All planned contract award by 2012 7. All planned manufacturing and delivery by 2013 8. Completion of overall physical construction by 2015			**Inputs** ($ million) (including contingencies) • ADB: $21.59 • Government/BPC: $2.75 • SNV: $0.27 • Users contribution: $0.30

Table C-12: Project Design and Monitoring Framework			
Design Summary	Performance Targets/Indicators	Data Sources/Reporting Mechanisms	Assumptions and Risks

Notes:

[1] JICA. 2010. *Survey on Preparing a Project Design Document of Clean Development Mechanism for Rural Electrification of Bhutan*. Tokyo. The GHG emission reduction was studied in preparing a project design document, after aggregating estimates from ongoing and proposed rural electrification projects of both JICA and ADB. Benefits from other renewable energy components under the project were also added.

[2] The gender-inclusive design is related to the project's major output of rural electrification on an-grid and off-grid basis which will cover more than 80% of the Project's cost. This gender-related output is expected to be supported and monitored by the gender mainstreaming initiative of the Improving Gender-inclusive Access to Clean and Renewable Energy in Bhutan, Nepal, and Sri Lanka, which is being considered separately for approval.

ADA = Austrian Development Agency, ADB = Asian Development Bank, BPC = Bhutan Power Corporation, GDP = gross domestic product, IMF International Monetary Fund, JICA = Japan International Cooperation Agency, NEC = National Environment Commission, UNDP = the United Nations Development Programme.

9.2 Monitoring

58. **Project performance monitoring.** IAs will undertake the overall monitoring of the Project in terms of progress. ADB, the government and EA/IAs will conduct semiannual reviews throughout the implementation of the Project. The review will monitor the project output quality, implementation arrangements, implementation progress, and disbursements.

59. **Compliance monitoring.** In addition to standard assurances, compliance with specific assurances will be monitored. They will be based on the Grant Agreement and Project Agreement as well as include Consulting Services, Procurement and Disbursement Guidelines. All consultants will be recruited according to ADB's *Guidelines on the Use of Consultants* (2010, as amended from time to time). The procurement of goods, related services, and works financed by the grant will follow procedures outlined in the ADB's *Procurement Guidelines* (2010 as amended from time to time). The grant proceeds will be disbursed in accordance with ADB's *Loan Disbursement Handbook* (2010, as amended from time to time.

9.3 Evaluation

60. ADB will basically field regular review missions every six months to review the status of contract awards, disbursements, physical progress, and implementation of the environmental and resettlement action plans. Within 6 months of physical completion of the Project, the EA will cause IAs to submit a consolidated Project completion report (PCR) to ADB. Subsequently, ADB will field a mission to finalize the PCR. Evaluation activities are summarized In Table C-13.

Table C-13: Evaluation Activities			
Evaluation Activity	**Purpose**	**Methodology**	**Who Responsible and Involved**
Review mission	Review the progress of the project and provide guidance to facilitate implementation	Site visit and meetings with EA officers, contractors, and consultants twice a year	ADB/ EA/IAs
Project completion report	Evaluate the overall output of the project and its relevance and suitability	Site visit and meetings with EA officers, contractors, and consultants	ADB/ EA/IAs

9.4 Reporting

61. The DOE will cause each of the IAs to provide ADB with quarterly progress reports in a format consistent with ADB's project performance reporting system and consolidated annual reports including 1) progress achieved by output as measured through the indicator's performance targets, 2) key implementation issues and solutions, 3) updated procurement plan, 4) updated implementation plan for next 12 months, and 5) safeguard issues if any. To ensure the Project continues to be both viable and sustainable, Project accounts, together with the associated auditor's report, should be adequately reviewed. These reports will provide information necessary to update ADB's project performance reporting system.[38]

9.5 Stakeholder Communication Strategy

61. This Strategy is summarized in Table C-14. Each of the IAs will post all relevant information on its website. The website will include, at a minimum, information regarding the bidding process, bidders, contract awards, and use of funds disbursed under the Project and physical progress.

Table C-14: Stakeholder Communication Strategy				
Project Information To Be Communicated	**Means of Communication**	**Responsibility**	**Audience**	**Frequency**
Report and Recommendation of the President (RRP) with linked documents	ADB website	ADB	ADB, Government including the EA and IAs	Once
Project information while	Discussions and	IAs	Project	Regular

[38] ADB's project performance reporting system is available at: http://www.adb.org/Documents/Slideshows/PPMS/default.asp?p=evaltool

Table C-14: Stakeholder Communication Strategy				
planning/ designing	stakeholder consultations		beneficiaries	intervals during planning and design
Project Performance Reports and Project Information Documents	ADB website	ADB	ADB, Government including the EA and IAs	Every quarter
Project completion report	ADB website	ADB	ADB, Government including the EA and IAs	Once

10. ANTICORRUPTION POLICY

63. ADB reserves the right to investigate, directly or through its agents, any violations of the Anticorruption Policy relating to the Project.[39] All contracts financed by ADB shall include provisions specifying the right of ADB to audit and examine the records and accounts of the executing agency and all Project contractors, suppliers, consultants and other service providers. Individuals/entities on ADB's anticorruption debarment list are ineligible to participate in ADB-financed activity and may not be awarded any contracts under the Project.[40]

64. To support these efforts, relevant provisions are included in the grant and project agreements and the bidding documents for the Project.

11. ACCOUNTABILITY MECHANISM

65. People who are, or may in the future be, adversely affected by the Project may address complaints to ADB, or request the review of ADB's compliance under the Accountability Mechanism.[41]

12. RECORD OF PAM CHANGES

To be provided

[39] Available at: http://www.adb.org/Documents/Policies/Anticorruption-Integrity/Policies-Strategies.pdf
[40] ADB's Integrity Office web site is available at: http://www.adb.org/integrity/unit.asp
[41] For further information see: http://compliance.adb.org/.

Appendix D
ON-GRID RURAL ELECTRIFICATION PROJECT TECHNICAL REPORT

1. BACKGROUND

1. The Royal Government of Bhutan (RGOB) has established an ambitious goal to provide electricity for all households in the country by 2013. The Asian Development Bank (ADB) is assisting the on-grid rural electrification through the provision of grants to the RGOB. This report summarizes the technical assistance provided to the implementing agency (IA), the Bhutan Power Corporation, in finalizing the technical designs, cost estimates and procurement documents for the on-grid rural electrification projects in six dzongkhags.

2. The rural reticulation program, referred as the Rural Electrification Project – 5 (RE5) is the fifth rural electrification project in Bhutan funded by the ADB. It is now reaching its final stage, during which the last lines will be extended to the most remote villages and households. Household load densities for these line extensions are at the minimum levels for the country.

3. Bhutan is a country of steep-sided mountain valleys, and lines traverse high and mountainous terrain to serve households in remote areas, often a few days' walk from the nearest road. Construction costs are relatively high due to the long distances involved and high transportation costs. Labor also incurs high accommodation costs. The costs per household connected are at therefore inevitably higher than those of previous rural electrification projects.

4. It is important, however, that the rural electrification projects are designed for low life cycle cost, low maintenance cost, and high reliability in order that operating and maintenance costs are also low. Line design must take into account the environmental conditions likely to be encountered, including high winds and snow in some areas.

2. OVERVIEW OF RE5 PROJECT DESIGN

5. For the RE5 rural electrification projects in Lhuentse, Mongar, Samdrupjonkhar, Trashigang, Trashiyangtse, and Zhemgang dzongkhags, the ADB and the Bhutan Power Corporation (BPC) have agreed on certain cost-saving economic designs. The agreed design

basis of the RE5 Project is a mixture of construction design deployed in previous projects (RE4) and more economic designs such as lighter telescopic poles and three-phase transformers, better ultra-violet protected service cables and lightning protection, and others. The following sections summarize the assessment of these agreed project designs.

6. The design of the rural distribution is based on overhead lines utilizing steel poles and steel reinforced aluminum conductors (ACSR). This is in line with British construction standards.

7. The reasoning for using a mixture of design and construction methods for RE5 is to utilize ADB-funded RE4 project saving ($4.888 million) by repeat orders to current RE4 foreign material suppliers. RE4 standard foreign materials (tubular steel poles and accessories) will be used for the 33 kV distribution lines in Zhemgang, and the 11 kV distribution lines in three other dzongkhags (Lhuntse, Mongar, and Trashigang). The new design using telescopic poles will be used for the 33 kV distribution lines in five dzongkhags (Lhuntse, Mongar, Samdrup Jongkhar, Trashigang, and Trashiyangtse).

8. The numbers of households to be connected, the type and voltage of distribution line, the total capacity of distribution transformers and the basis of the line construction for each of these dzongkhags is given in the Scope of Work in Table D-1.

Table D-1. Summary Scope of Work (RE5 Net of RE4 Materials Savings)

dzongkhag	No. Households	33 kV Line Construction	110 kV Line Construction	LV Line Construction 50 mm LV ABC	Distribution Substations (No. in Parentheses)
Lhuentse	170	2.75 km telescopic poles	26.36 tubular steel poles	12.75 km telescopic poles	33 kV: (2) 41 kVA 11 kV: (14) 311 kVA
Mongar	1,646	140.93 km telescopic poles	31.01 km tubular steel poles	137.75 km telescopic poles	33 kV: (142) 2,935 kVA 11 kV: (10) 217 kVA
Samdrup Jongkhar	1,062	82.38 km telescopic poles	N/A	76.13 km telescopic poles	33 kV: (63) 1,386 kVA
Trashigang	82	7.61 km telescopic poles	21.85 km tubular steel poles	7.31 km telescopic poles	33 kV: (5) 125 kVA 11 kV: (1) 25 kVA
Trashi Yangtse	389	37.57 km telescopic poles	N/A	34.67 km telescopic poles	33 kV: (30) 833 KVA
Zhemgang	1,726	225.12 km tubular steel poles	N/A	141.51 km tubular steel poles	33 kV: (144) 3,403 KVA
Total	5,075	496.36 km	79.22 km	410.12 km	33 kV: (386) 8,723 KVA 11 kV: (25) 553 kVA

9. As can be seen, the project has line construction types and two distribution voltages. Line construction types are tubular steel poles and telescopic poles. The tubular steel pole construction is the design on which the RE4 Project was based. The Telescopic Pole design has been completed and a pilot line project has been successfully completed. BPC has completed full designs for both construction types.

10. Distribution voltages of 33 kV and 11 kV are used. These voltages have resulted from an incremental economic continuation of historical distribution systems. The low load density conditions of rural Bhutan lend themselves to the continued extension of lines until the constraints of voltage swing over the load range are reached. It will be possible in future to remove existing voltage constraints and extend the current loading limits through the deployment of voltage support devices such as voltage regulators and shunt capacitors.

2.1 MV Distribution Lines

11. MV Reticulation is generally 3-phase (3-wire) for main feeder lines. Spur lines may be either 3-phase (3 wires) or 1-phase (2 wires) where single phase low-voltage supply is acceptable. Single wire earth return (SWER) is not a practicable option in Bhutan primarily due to the poor earthing conditions of the thin layer of top soils and rocky substructures.

12. At present, two conductor sizes have been settled on as standards. These are “RABBIT” and “DOG” conductors. Table D-2 shows the characteristics of these conductors.

Table D-2: Conductor Specifications

	Rating (A)	Mass/km	Breaking Load (kN)
RABBIT	200	210	18.4
DOG	297	394	32.7

13. The two standard line designs are applied to both 33 kV and 11 kV distribution lines. The line designs are based on the heavier of the conductors, which is DOG. One design is based on tubular steel poles; the other is based on 11 m telescopic poles.

14. The two standard line designs have the advantage that future conductor upgrades from the lighter conductor will be able to be accommodated without changes to the existing poles structures.

15. Given the climatic conditions prevailing in Bhutan, the designs are acceptable from a structure and conductor strength point of view. It is noted that conditions of heavy snow loadings are likely only in the northern districts and that most lines are in the southern (lower altitude) districts. The line designs will support the heaviest conductors in the worst case conditions in the country. There is thus scope for some optimization of the single standard design that would allow for reduced strength line design in areas where heavy snow conditions

are unlikely. This would deploy fewer poles per unit line length with a commensurate reduction in capital costs.

2.2 Distribution Substations

16. Distribution substations are also of a single standard design for each distribution voltage and irrespective of substation capacity. These are based on two pole structures with an overhead transformer support platform, MV drop out fuses and lightning arrestors. Each substation also has a low-voltage distribution fuse panel, which is mounted at the substation near ground level.

17. This standardized design will provide for easy capacity upgrade by transformer replacement should the substation load increase significantly. However, it carries the disadvantage of high overall average cost, particularly when the average capacity is low. This is the case in the RE5 Project.

2.3 Low-Voltage Reticulation

18. Historically, low-voltage reticulation has consisted of an open 3-phase (4-wire) design using mainly bare aluminum conductors, strung in vertical configuration on 7.5 m steel poles. This type of reticulation is evident throughout much of Bhutan.

19. For the RE5, the low-voltage reticulation is to be based on aerial bundled conductor (LV ABC). This is a low CSA aluminum conductor that is fully insulated. It consists of two or four insulated cores twisted together as a composite aerial cable. Specially designed fittings are used to allow fixing and suspension from poles, and piercing of the cable insulation for the connection of service drops, etc.

20. LV ABC offers the advantages over open wire construction of improved aesthetic effect, improved safety and high reliability. The bundling of phase conductors also reduces line impedance, which provides improved line voltage regulation for the same line loading, over open wire reticulation. As the conductors are fully insulated and bundled, they occupy less space. This leads to reduced ongoing operating costs from a reduced requirement for vegetation clearance, etc.

3. PROJECT COST ESTIMATES

21. The cost estimates of the RE5 development based on the design and Scope of Work summarized in the previous section are given in Table D-3.

Table D-3. Cost Estimates for RE5						
dzongkhag	Foreign Materials		Foreign Materials Total	Total Civil Works	Total Project Cost	No. of Households
	RE5	RE4				
Lhuentse	$173,288	$176,044	$349,311	$316,276	$655,607	170
Mongar	$3,705,933	$628,162	$4,334,095	$2,111,765	$6,455,860	1,646
Samdrupjongkhar	$2,926,234		$2,926,234	$1,101,629	$4,027,863	1,062
Trashigang	$248,129	$80,902	$329,031	$263,179	$592,211	82
TrashiYangste	$800,301		$800,301	$448,857	$1,249,159	389
Zhemgang	$713,185	$4,022,892	$4,716,077	$2,685,507	$7,401,584	1,762
Total	$8,567,070	$4,888,000	$13,455,070	$6,927,213	$20,382,283	5,075

Note: Includes $4.888 million in materials purchased under ADB RE4 and contingency. Excludes the costs of overhead and administrative and environmental management plan.

The above figures include the following contingencies:

- Materials costs for RE5 are based on the BPC rates (2008) +20% escalation + 15% contingencies
- The labor unit price of Nu 250/day and transportation cost are to be increased 20% because of the longer distance
- 10% for physical contingency and 5% for price contingency for all components, except the RE4 purchasing materials.
- Civil works costs are further broken down in Table D-4:

Table D-4: ADB RE5 Cost Estimates by dzongkhag (including Contingencies), $							
dzongkhag	Civil Works						Total Civil Works
	Materials	Road Transport	Local Transport	Head Loading	Erection	Tree Trimming	
Lhuentse	12,312	35,352	8,584	127,429	121,472	11,126	316,276
Mongar	51,804	228,644	55,010	930,317	780,281	65,710	2,111,765
S J	24,581	180,101	26,223	456,557	373,683	31,483	1,101,629
Trashigang	10,471	26,519	6,537	107,233	101,164	11,255	263,179
TrashiYangtse	11,218	49,895	11,506	188,330	173,549	14,359	448,857
Zhemgang	105,528	277,934	72,705	1,144,554	998,753	86,034	2,685,507
Total	215,914	798,455	180,564	2,963,420	2,548,903	219,967	6,927,213

4. NEW DESIGN ASPECTS ADOPTED FOR RE5

22. As part of the Technical Assistance for the RE5 Project, the consultant has been asked to comment and advise on the aspects of the design that are being introduced in the RE5 Project. The individual aspects are dealt with in the following subsections.

4.1 Telescopic Poles

23. As a means of reducing the difficulties faced with the increased manual transportation of materials in remote mountainous areas in RE5, the decision has been taken to utilize a tapered cylindrical sectionalized pole. This allows poles to be carried in 2.5 m sections, making for easier and safer work by the laborers. Once on site, the poles can be readily assembled and dressed for erection. The telescopic poles have been widely used in similar mountainous areas in Nepal.

24. The telescopic poles have various lengths and strengths and can be customized for special applications as required. Being cylindrical, these poles have symmetrical strength in the in-line and cross-line directions. They have moderate torsional strength, but again because they are cylindrical, accessories such as cross-arms can be designed to provide a torsional fusing effect. This is a useful feature when designing mechanical failure mechanisms lines to avoid cascade support failure. This can occur when lines are subjected to severe asymmetrical loading such as when conductor breakages occur under extraordinary heavy snow loading conditions.

25. A review of the poles reveals that pole strengths suitable for the rural reticulation are available. BPC has gained experience in procuring and using telescopic poles and accessories in a recent RE project. The following pole types are recommended for RE5.

Table D-5: Recommended Telescopic Poles

Item	Overall Length	No Sections	Max Loading 600 mm from top
B26	11 m	5	3.29 kN
B25	9 m	4	3.29 kN

26. The Bhutan Power Corporation noted that difficulties had been experienced assembling the poles at times, particularly in cold conditions when metal contraction had made fitting tolerances tight. One solution had been to heat the outer section to cause it to expand and fit more easily. This practice will likely damage the galvanized coating of the pole, and shortening the life of the pole due to accelerated corrosion. It is recommended that the problem be taken up with the manufacturers who may be able to alter manufacturing tolerances to accommodate a wider range of temperature conditions for assembly.

27. The adoption of the telescopic poles has provided the advantage of access to a taller and stronger pole. This means that longer average spans are attainable, and fewer poles per km of line are required to support the same conductor. The average number of B26 telescopic poles per km can be reduced to 16, whereas 20 of the 10 m steel tubular poles were previously required.

4.2 Polymer Strain Insulators

28. BPC has considered the adoption of polymer strain insulators for use in its RE5 reticulation. These are lightweight but strong insulators of composite construction. A strong inner insulating rod typically of glass fiber material has aluminum alloy end fittings compressed onto it. The inner rod is over sheathed with a UV resistance and hydrophobic silicon rubber compound that is formed in the shape of water sheds. This extends the surface leakage paths and provides a long life, weather-resistant outer insulation and protection for the structural inner rod.

29. The technology of polymer strain insulators has evolved over the past 25 years and is now stable and mature. Polymer strains have been installed in many networks all over the world, and are now a proven highly reliable insulation.

30. The main advantage of polymer strain insulators over the previous glass or porcelain technologies is their light weight. A single 33 kV polymer strain weighs approximately 1.5 kg, whereas a 3 disc porcelain insulator weighs approximately 7 kg. They are also less fragile as they do not chip or crack when dropped. These will prove to be major advantages in the RE5, where as previously detailed, all equipment is required to be transported to remote mountainous areas manually. In addition, polymer strain insulators are less prone to insulation puncture from lightning surge than porcelain or glass discs, and will give an improved overall reliability performance in rural Bhutan.

31. The length of the insulator varies with its voltage rating: 33 kV units are longer than 11 kV. This makes the identification of the insulator voltage unmistakable. They can also be purchased to be of a similar length to the disc assemblies, allowing for direct replacement of disc assemblies without the need to re-sag the conductors.

32. There is no international standard for polymer insulators, but a specification suitable for use in Bhutan against which suppliers may tender are provided in the procurement document submitted to BPC. Cost savings on the order of 30% over the installed costs of porcelain or glass discs can be expected from the deployment of polymer strain insulators.

33. The recommended specifications for high silicon content 33 kV and 11 kV polymer strain insulators are shown in Table D-6.

Table D-6: Recommended Polymer Insulator Specifications		
	11 kV Strain Insulators	33 kV Strain Insulators
Specified design tension (kN)	35	35
90-second proof strength (kN)	70	70
Min torsion strength (Nm)	47	47
Min dry 50 Hz flashover (kV)	110	200
Min wet 50 Hz flashover (kV)	75	160
Min impulse flashover (kV)	140	325

4.3 Covered AAAC Conductor in Environmentally Sensitive Areas

34. There are a number of instances in the RE5 project where lines will be constructed through native vegetation or areas of high ecological value. Medium-voltage lines are required to be kept clear of vegetation, not only for the avoidance of damage to the power lines but also for the avoidance of fires in dry windy conditions. Covered AAAC is an all-aluminum alloy conductor that has a black UV-resistant PVC covering.

35. Covered conductors provide a measure of protection against fire in environmentally sensitive areas by limiting the propagation of arcs along conductors that are brought in close proximity to each other. The covering is not a full working voltage covering and will therefore not eliminate arcing when conductors are clashed together; however, the covering will reduce the propensity for an arc to move along the conductor or strike between conductors that are in close proximity but not touching.

36. In order to maximize the life of the PVC covering, special precautions are advisable when using this conductor at higher voltages. When bound on to insulators, the covering layer forms a dielectric capacitor between the conductor and the insulator surface. This capacitor is in series with the capacitance of the insulator and a capacitive voltage divider is set up dividing the phase to ground voltage between these two capacitors. This voltage division causes a voltage stress in the PVC covering.

37. Over time this stress causes an electrical discharge to occur in the PVC, resulting in radio frequency emissions and erosion of the PVC covering. The higher the line voltage, the greater the effect will be. To avoid this, it is recommended that the covering layer be stripped off the conductor so that the inner aluminum is directly in contact with the porcelain insulator.

38. Similarly, when terminating this covered conductor on medium voltage lines it is recommended that the PVC covering be removed and the bare aluminum alloy pre-form dead-end (correctly fitting) is in direct electrical contact with the metallic conductor.

4.4 Lightning Performance Improvement by Shield Wire

39. In the Samdrup Jongkhar dzongkhag, there is a high incidence of lightning. This has resulted in regular disruption to supply and damage to line and transformer insulation.

40. The BPC has taken the decision to incorporate overhead shield wires in its distribution line design in this dzongkhag as a means of reducing the effect of the lightning on its lines and thereby improving the line performance.

41. The installation of the shield wire is unlikely to significantly improve lightning performance. The reasoning for this view is two fold:

- For direct strokes to poles or to the shield wire, it is necessary for all poles to be solidly earthed, having resistances to ground of less than approximately 10 ohms for 11 kV lines and less than 20 ohms for 33 kV lines. In the dry and stony soils of Bhutan it is extremely unlikely that earth resistances will be obtainable. Without these low resistances, pole structures are elevated during lightning strokes to levels beyond the flashover strength of the insulators and the phenomenon of "back flashover" occurs and the line is tripped out.

- For induced strokes, traveling surges of liberated positive charge on the line results. The attenuation of these surges as they travel along the line is dependent on the surge impedance of the line. The shield wire will serve to bring down the surge impedance and provide additional attenuation. However, when there is a change in surge impedance such as when a distribution transformer is connected, then a partial reflection of the surge occurs, which results in a surge voltage increase at the point of step change in impedance. Surge control at these points is best managed through the use of lightning arrestors, which limit the surge voltage impressed on the device it is protecting, discharging the residual charge to ground. Properly placed and specified lightning arrestors will give excellent lightning protection and preclude the need for any shield wire protection on distribution lines.

42. The BPC plans to install the shield wire over some 200 km of distribution line in the Samdrup Jongkhar dzongkhag. A review of the construction designs for this installation did not reveal any issue with them as a shield wire design.

4.5 Network Reliability Improvement through the Use of AutoReclosers, Isolators, and Line Fuses

43. In rural networks where long radial lines are used to supply dispersed connections, the use of autoreclosing circuit breakers (reclosers) in conjunction with other devices such as air

break isolators and line fuses, can significantly improve the average supply reliability to consumers, by allowing for the automatic reliving of lines affected by transient faults and by allowing for automatic sectionalizing of lines affected by permanent faults so that the minimum number of consumers only are left without supply. When the main line or a long spur line has a permanent fault, air break isolators provide a quick and efficient means for lineman to break the line into sections that can be test livened one by one in order to identify and isolate the section where the fault is located.

44. The optimum configuration and positioning of these devices to achieve the most cost-effective solution is best determined by a system protection study. Such a study would consider the consumer density variations along the line and the likely sections of line that would be most subject to faults due to environmental conditions such as vegetation, lightning, etc. A probabilistic analysis is then undertaken to determine the optimum positioning of devices for maximum overall reliability performance. The protection study would also prescribe operating settings for the devices that would allow automatic operating coordination between reclosers and downstream fuses so that the fuse operates to clear a fault downline from it and allow the recloser to restore supply to the unaffected area.

45. The BPC wishes to deploy some reclosers in its RE5 network for the purposes of improving system reliability. Without completing a full system study, it is recommended that, on the basis of practices in other countries:

- One recloser is provided for each 50 km of line.
- One air break isolator is installed every 10 km along the main line.
- A set of line section fuses is provided at the connection of each spur line to the main line.

46. It is also recommended that a rural system protection study be undertaken to optimally position these devices.

47. It should also be noted that the BPC has standardized on the Nulec N Series recloser, which is supplied by Schneider Electric. We recommend this recloser as suitable for use in Bhutan and concur with the decision to standardize on recloser types. Standardization provides for efficient future operations and minimizes installation, configuration and operator training for the company.

48. Allowance for the procurement of reclosers, air break switches and line fuses in line with the above recommendations has been made in the procurement documents submitted to the BPC.

4.6 Ultra Violet Performance of PVC Service Cables

49. The BPC has requested comments on the UV performance of its PVC insulated and sheathed service cables. Historically, PVC has had good ultraviolet resistance and modern service cables are produced with a degree of carbon black compound that gives the PVC material its UV resistance. There is thus no need to move from PVC as the primary insulation and sheathing for service cables.

50. Cross-linked polyethylene (XLPE) has poor UV performance, however, and any bare tails from XLPE insulated cables that are exposed to sunlight should be covered in heat-shrinkable UV-resistant sleeving.

4.7 Use of Preform Terminations for Stay Wires

51. The consultants concur with the use of preform terminations for stay wires. These are an efficient and effective means of securing stay wires.

5. PROCUREMENT DOCUMENTS

52. Table D-7 summarizes the 13 RE5 procurement packages prepared for the BPC’s review. PA and BPC prepared the standard bidding document for each package, including the terms and conditions of the contract, technical specifications, bill of quantities and drawings. These documents are available at the BPC.

Table D-7: ADB RE5 Procurement Packages

RE5 Procurement Packages					
Contract No.	**Description**	**Quantities**	**Unit Cost**	**Total Base Cost**	**Cost by Package**
		No	USD	USD	USD
Package 1: Telescopic Poles					2,367,347
1-1	B26 11 m Telescopic Poles	4,562	405.60	1,850,347	
1-2	B25 9 m Telescopic Poles	1,551	333.33	517,000	
Package 2: Telescopic Pole Fittings and Accessories					421,824
2.1	33kV Single Pole Cross Arm	1,026	21.48	22,038	
2.2	11kV Single Pole Cross Arm	0	16.92	0	
2.3	33kV top Hamper Assembly	962	11.44	11,001	
2.4	11kV top Hamper Assembly	0	9.18	0	
2.5	33 H Frame Cross Arm Assembly	1,539	88.03	135,481	
2.6	11kV H Frame Cross Arm Assembly	0	70.13	0	
2.7	33kV Cross Brace Arm Assembly	1,539	63.00	96,957	
2.8	11kV Cross Brace Arm Assembly	0	63.00	0	
2.9	Substation Cross Arm	229	84.35	19,316	
2-10	Transformer Mounting Platform	229	137.80	31,555	
2-11	M.S. Channel Support	458	93.97	43,039	
2-12	Steel Support for Lightening Arrester	229	33.05	7,568	
2-13	LV Distribution Pillar Support	229	78.04	17,870	
2-14	Steel Support for 11kV & 33kV ABS	2	78.04	156	
2-15	Steel Support for ABS Handle	2	66.11	132	
2-16	Steel Support for ABS Intermediate	2	33.05	66	
2-17	Steel Support for Jumpers	2	33.05	66	
2-18	Danger Plate 33kV	4,562	3.14	14,343	
2-19	Danger Plate 11kV	0	3.14	0	
2-20	Stay Clamp Assembly, 33kV (Telescopic Pole)	3,536	6.29	22,234	

Package 3: MV Overhead ACSR Conductors					1,025,814
3.1	ACSR Conductor, Dog 100 mm^2	771	1,320.00	1,017,720	
3.2	ACSR Conductor, Rabbit 50 mm^2	12	675.60	8,094	
Package 4: Insulators					516,124
4-1	Porcelain Insulators 33kV Disc (70kN)	0	29.39	0	
4-2	Porcelain Insulators 11kV Disc (70kN)	0	14.43	0	
4-3	Polymer Strain Insulators 33kV	10,236	30.69	314,186	
4-4	Polymer Strain Insulators 11kV	0	14.43	0	
4-5	Porcelain Insulators 33kV Pin (ANSI C29.6)	11,147	17.48	194,894	
4-6	Porcelain Insulators 11kV Pin (ANSI C29.6)	0	7.20	0	
4-7	Porcelain Insulators 33kV Stay	3,536	1.99	7,044	
4-8	Porcelain Insulators 11kV Stay	0	2.08	0	
Package 5: Covered AAAC Conductors, LV ABC, and PVC Cables					401,501
5-1	Covered AAAC Conductor 120 mm^2	0	1,769.38	0	
5-2	Covered AAAC Conductor 80 mm^2	0	1,026.00	0	
5-3	LV ABC Conductor, 4 Core, 50 mm^2	84	2,923.20	246,367	
5-4	LV ABC Conductor, 2 Core, 50 mm^2	51	1,453.20	74,782	
5-5	LV ABC Conductor, 4 Core, 95 mm^2	0	5,666.40	0	
5-6	LV ABC Conductor, 2 Core, 95 mm^2	0	2,817.60	0	
5-7	PVC Insulated Cable, 500V, 2Core, 4 mm^2	33	1,500.00	49,464	
5-8	PVC Insulated Cable, 500V, 2Core, 6 mm^2	6.2	1,992.00	12,317	
5-9	PVC Insulated Cable, 500V, 2Core, 10 mm^2	2	2,982.00	6,146	
5-10	PVC Insulated Cable, 500V, 4Core, 10 mm^2	2	5,232.00	12,086	
5-11	2Core, 650/1100V, 70mm2, PVC Cable	41	7.58	313	
5-12	4Core, 650/1100V, 70mm2, PVC Cable	2	11.70	27	
5-13	4Core, 650/1100V, 150mm2, PVC Cable	0	28.90	0	
Package 6: Earthing Equipment					262,443
6-1	Spike Earthing Set 2500x20 mm	4,104	10.00	41,024	
6-2	Pipe Earthing Set, 2500 x 40 mm	687	24.77	17,016	
6-3	Earthing Conductor, GI Strip 25x6 mm (m)	16,488	1.64	27,106	
6-4	G.I. Stay Set Assembly	4,422	26.77	118,386	
6-5	Barbed Wire (kg)	0	1.78	0	
6-6	G.I. Stay Wire 7/8 SWG (kg)	33,171	1.78	58,912	

Package 7: Distribution Transformers					727,963
7-1	1P Transformer 33/0.240kV, 10kVA	25	2,361.74	59,044	
7-2	1P Transformer 33/0.240kV, 16kVA	50	2,411.64	120,582	
7-3	1P Transformer 33/0.240kV, 25kVA	16	2,503.12	40,050	
7-4	3P Transformer 33/0.415kV, 16kVA	0	2,518.82	0	
7-5	3P Transformer 33/0.415kV, 25kVA	134	3,667.36	491,426	
7-6	3P Transformer 33/0.415kV, 63kVA	4	4,215.47	16,862	
7-7	3P Transformer 33/0.415kV, 125kVA	0	4,899.60	0	
7-8	1P Transformer 11/0.240kV, 10kVA	0	2,315.41	0	
7-9	1P Transformer 11/0.240kV, 16kVA	0	2,380.75	0	
7-10	3P Transformer 11/0.415kV, 16kVA	0	3,486.78	0	
7-11	3P Transformer 11/0.415kV, 25kVA	0	3,593.70	0	
7-12	3P Transformer 11/0.415kV, 63kVA	0	3,920.40	0	
7-13	3P Transformer 11/0.415kV, 125kVA	0	5,995.84	0	
Package 8: MV Overhead Conductor Fittings and Accessories					64,219
8-1	P.G. Clamp for RABBIT	1,291	0.96	1,239	
8-2	P.G. Clamp for DOG	8,945	1.22	10,949	
8-3	Insulated Piercing Conductor & Insulation Cover	14	1.68	24	
8-4	Preform Dead End Terminals - RABBIT	1,263	1.12	1,410	
8-5	Preform Dead End Terminals - DOG	8,945	3.73	33,383	
8-6	Preform Dead End Terminals - Covered AAAC	28	2.24	63	
8-7	Terminal Lugs - RABBIT	2,384	0.47	1,116	
8-8	Terminal Lugs - AAAC (49.98 mm^2)	0	0.37	0	
8-9	Terminal Lugs for 70 mm^2 Cable	1,468	0.44	652	
8-10	Terminal Lugs for 150 mm^2 Cable	0	1.13	0	
8-11	Terminal Lugs for 50 mm^2 LV ABC	443	0.37	165	
8-12	2 Core, 70 mm^2 U/D Cable Glands	182	1.86	339	
8-13	4 Core, 70 mm^2 U/D Cable Glands	276	3.02	835	
8-14	4 Core, 150 mm^2 U/D Cable Glands	0	4.64	0	
8-15	2 Core, 50 mm^2 LV ABC Glands	182	1.51	275	
8-16	4 Core, 50 mm^2 LV ABC Glands	414	3.02	1,252	
8-17	Tension Joints - RABBIT (Modspan)	25	2.78	70	
8-18	Tension Joints - DOG (Modspan)	2,236	5.57	12,450	
8-19	Tension Joints - Covered AAAC 80mm	0	1.32	0	

Package 9: LV ABC Cable Fittings and Accessories					57,310
9-1	Hook Bolt Assembly	1,994	4.40	8,782	
9-2	Insulated Piercing Conductor (IPC 50/50mm2)	886	4.72	4,178	
9-3	Insulated Piercing Conductor (IPC 95/95mm2)	0	4.90	0	
9-4	Strain Clamp for 4 Core 50 mm^2 LV ABC	549	15.47	8,492	
9-5	Strain Clamp for 2 Core 50 mm^2 LV ABC	337	15.47	5,213	
9-6	Strain Clamp for 4 Core 95 mm^2 LV ABC	0	15.47	0	
9-7	Strain Clamp for 2 Core 95 mm^2 LV ABC	0	12.70	0	
9-8	Suspension Clamp (S) for 4 Core 50 mm^2 ABC	469	10.32	4,840	
9-9	Suspension Clamp (S) for 2 Core 50 mm^2 ABC	416	10.32	4,293	
9-10	Suspension Clamp (S) for 4 Core 95 mm^2 ABC	0	10.32	0	
9-11	Suspension Clamp (S) for 2 Core 95 mm^2 ABC	0	7.85	0	
9-12	Suspension Clamp (L) for 4 Core 50 mm^2 ABC	137	15.36	2,104	
9-13	Suspension Clamp (L) for 2 Core 50 mm^2 ABC	84	15.36	1,290	
9-14	Suspension Clamp (L) for 4 Core 95 mm^2 ABC	0	27.90	0	
9-15	Suspension Clamp (L) for 2 Core 95 mm^2 ABC	0	15.36	0	
9-16	Set of Terminal Caps for 50 mm^2 ABC	443	2.84	1,260	
9-17	Set of Terminal Caps for 95 mm^2 ABC	0	2.84	0	
9-18	Insulation Tension Joint Sleeve, 50 mm^2 ABC	665	2.33	1,548	
9-19	Insulation Tension Joint Sleeve, 90 mm^2 ABC	0	3.89	0	
9-20	Insulated Service T-off Conductor 50 to 4 mm^2	2,198	3.49	7,675	
9-21	Insulated Service T-off Conductor 50 to 6 mm^2	412	3.49	1,439	
9-22	Insulated Service T-off Conductor 50 to 10 mm^2	275	3.49	960	
9-23	Service Dead End for 2 Core 4 mm^2 Cable	2,198	1.67	3,666	
9-24	Service Dead End for 2 Core 6 mm^2 Cable	412	2.23	920	
9-25	Service Dead End for 2 Core 10 mm^2 Cable	137	2.23	306	
9-26	Service Dead End for 4 Core 10mm2 Cable	154	2.23	344	

Package 10: Switching Equipment and Accessories					863,180
10-1	33kV DO Fuse Unit (1set=2DO fuses)	91	138.00	12,558	
10-2	33kV DO Fuse Unit (1set=3DO fuses)	138	222.00	30,636	
10-3	33kV HRC Fuse Element, 3A	596	1.22	730	
10-4	33kV HRC Fuse Element, 6A	210	1.68	353	
10-5	11kV DO Fuse Unit (1set=2DO fuses)	0	92.16	0	
10-6	11kV DO Fuse Unit (1set=3DO fuses)	0	138.24	0	
10-7	11kV HRC Fuse Element, 3A	0	1.03	0	
10-8	11kV HRC Fuse Element, 10A	0	1.67	0	
10-9	11kV HRC Fuse Element, 20A	0	1.82	0	
10-10	33kV Air Break Switch	28	840.00	23,520	
10-11	11kV Air Break Switch	0	600.00	0	
10-12	30kV, 5kA Lightning Arrestor (1 set=2nos.)	91	138.00	12,558	
10-13	30kV, 5kA Lightning Arrestor (1 set=3nos.)	138	200.40	27,655	
10-14	9kV, 5kA Lightning Arrestor (1 set=2nos.)	0	69.60	0	
10-15	9kV, 5kA Lightning Arrestor (1 set=3nos.)	0	102.00	0	
10-16	MCB 10A, SP with 2P 10A ELCB	1,305	39.60	51,678	
10-17	MCB 20A, SP with 2P 10A ELCB	69	39.60	2,732	
10-18	MCB 60A, SP with 2P 10A ELCB	77	70.80	5,452	
10-19	1P LV Distribution Board 100A	0	349.68	0	
10-20	3P LV Distribution Board 100A	134	418.98	56,143	
10-21	3P LV Distribution Board 200A	4	622.09	2,488	
10-22	33kV Recloser	14	35,157.60	492,206	
10-23	11kV Recloser	6	24,078.42	144,471	
Package 11: Energy Meters					24,140
11-1	Energy Meters (1P, 2.5/10A)	1,099	14.38	15,799	
11-2	Energy Meters (1P, 5/20A)	206	14.38	2,961	
11-3	Energy Meters (1P, 10/40A)	69	14.52	1,002	
11-4	Energy Meters (3P, 10/60A)	77	56.86	4,378	
Package 12: Shield Wire Materials					717,760
12-1	Galvanised Steel Shield Wire (km)	220	933.33	205,333	
12-2	Shield Wire Pole Strain Attachment Fitting	4,800	11.11	53,333	
12-3	Shield Wire Pole Suspension Attachment Fitting	1,600	9.16	14,649	
12-4	Pole Extension	4,000	111.11	444,444	
Package 13: Civil Works					6,023,664
13	Civil works (by various small contracts)			6,023,664	
	Total Cost			13,473,290	13,473,290

Contingencie	**Local**	15%	903,550
	Foreign	15%	1,117,444
	Local Cost		6,927,213
	Foreign Cost		8,567,070
	Total Cost RE5		**15,494,283**

6. ALTERNATIVE LEAST-COST DESIGN AND LOAD FLOW ANALYSIS

6.1 Alternative Least-Cost Design

53. The consultants had identified an alternative least-cost design for the BPC to consider for the implementation of RE5. This design option was based on the use of a lightweight high-strength conductor that is suitable for the conditions in Bhutan and is used in other countries to electrify low-load density remote rural areas. However, the BPC expressed concerns about the difficulty in procuring, operating, maintaining, and managing spare parts if the recommended new conductor were used, especially only for the last phase (RE5) of rural electrification in Bhutan. Thus, it did not adopt this alternative for the RE5.

6.2 Load Flow Analysis

54. The BPC has purchased the MI-Power power system analysis software and its staff has been trained on using the software to perform load flow studies. As part of the TA, the consultants have reviewed and assessed the current status and operation of load flow modeling at the BPC.

55. **Network Model.** The network analysis model was accessed and inspected by the consultant by sampling sections of load flow model data and comparing them with GIS records. The network analysis model appears to be well constructed with line and substation data correctly entered. Line lengths appeared to be correct against GIS records. Runs of the model showed that line connections and switch status had been correctly modeled

56. **Load Data.** Load data were inspected to assess the accuracy of load magnitude against the type of consumer load being supplied. Despite the type of consumer load being consistent across the network, there was significant variation in peak loads per consumer modeled in different parts of the network. The loads modeled did not appear to take into account load diversity as well.

57. Load flow analysis should be carried out to accurately model the current and actual state of the network. This is necessary to verify that the model developed is a close representation of the real electricity network. Only when this has been achieved can the model be used to confidently predict the performance of the network under various conditions, such as future higher network loadings or alternative supply configurations that may be required under emergency conditions.

58. It is recommended that non-coincident peak demands from actual metered points on the network be compared with the values obtained from the load flow model to verify that the load data input to the model were correct.

59. It was also noted during inspection that all load power factors were modeled at 0.85. It is unrealistic that any electrical network would ever carry all loads at such low power factors. The result of modeling end use loads with such low power factors is the prediction of an extreme voltage drop. These results may not be useful to the BPC as it is not practicable to plan for a rural network to carry the extreme reactive power loadings required by such low power factor loads. In practice, economics will dictate that power factor correction of loads at the consumer premises would be undertaken before reinforcing the network infrastructure. The BPC indicated that the current regulations require the use of a minimum power factor of 0.85 for planning and operating the power network.

60. Observation of the type of loads evident in rural Bhutan gives a clear indication that the peak load power factors will be much higher than 0.85. This is due to the peak loadings being dominated by domestic rice cooking and lighting initially, and possible water and space heating in the future. These end uses are resistive loads that operate at unity power factor. It is thus expected that average load power factors will be higher than the 0.85 currently modeled in the BPC load flow models.

61. It recommended that power data from the field be compared with modeled data to verify the actual network conditions, and the model data be adjusted accordingly. Following this it will be possible to check that the load flow model is a realistic representation of the actual network. This will provide the BPC with a degree of confidence in its load flow model and allow it to extract value from its investment in load flow for the future as intended.

Appendix E

DRAFT MEMORANDUM OF UNDERSTANDING ON SOLAR HOME SYSTEM O&M SERVICES

Draft Memorandum of Understanding

Between

Department of Energy,
Ministry of Economic Affairs
Thimphu, Bhutan

and

Bhutan Power Corporation Limited
Thimphu, Bhutan

for the Operation and Maintenance Program of Off-grid Solar Home System in Bhutan

Dated _____ 2010

PARTIES TO THE MEMORANDUM

This Memorandum of Understanding (hereinafter, “MoU”) is made and entered into on this ___ day of ________ 2010, between the Department of Energy (hereinafter, “DOE”), Ministry of Economic Affairs and Bhutan Power Corporation Limited (hereinafter, “BPC”) in Thimphu, Bhutan.

1. PREAMBLE

1.1 The Rural Electrification Master Plan developed in 2005 identified the remaining number of households to be provided with either on-grid or off-grid electrification to achieve 100% electrification in Bhutan by 2020. Since 2006, the Royal Government of Bhutan (RGOB) has started installing solar home systems (SHS) for the households in the identified off-grid villages. In 2008, the RGOB established an accelerated goal of Electricity for All by 2013.

1.2 The proposed off-grid rural electrification project, expected to be funded by the ADB, will install SHS for the households in the remaining un-electrified off-grid villages by 2013. In addition, the proposed off-grid rural electrification project includes an operation and maintenance program designed to ensure that all the existing and to-be-installed SHS function properly in the long run,

1.3 Recognizing the mandate of the DOE as the policy making body for the energy sector and the BPC as the utility company responsible for power supply procurement, and construction, operation and maintenance of power networks in the country,

1.4 Acknowledging the necessary efforts being made by the BPC to provide on-grid rural electrification and the efforts being made by the DOE to provide off-grid rural electrification, mainly through solar home systems to achieve electricity for all,

1.5 Acknowledging the challenges posed by the geographical terrain, scattered nature of settlements and limited access to other complementary infrastructures to maintain and sustain the rural energy services and infrastructures functional at the optimum levels,

1.6 Recognizing the resources that would be required to build institutional capacities at various levels to maintain both on-grid and off-grid energy services,

1.7 Recognizing the Bhutan Power Corporation’s Electricity Services Divisions (ESD) based in each district and Customer Service Centers (CSC) throughout the country as the institutional strength that can be leveraged for the delivery of energy-related services covering both on-grid and off-grid areas that is cost-effective and responsive to BPC’s corporate social responsibility,

1.8 Recognizing the fact that the DOE, as the policy making institution, is not appropriately placed to look after the operational aspects of the rural energy services as the provision of rural energy services requires expansion and representation at the local community levels,

1.9 Intending to synergize the common efforts of the two parties for enhancing operational efficiency and effectiveness of delivering rural energy services, both parties have agreed to abide by the general provisions stipulated under this MoU.

2. GENERAL PROVISIONS

2.1 This MoU is limited to the operation and maintenance of the existing and to-be-installed solar home systems proposed under the off-grid rural electrification program to achieve the goal of electricity for all.

2.2 This MoU will be effective for three years starting January 2011, and can be extended with the consent of both parties, or cancelled by either party with one-month advance notification with specific reasons.

A. Responsibilities of the DOE

(I) Training

2.3 The DOE shall provide an initial off-grid SHS operation and maintenance service training followed up with annual refreshment trainings to at least 120 BPC village technicians.

2.4 The DOE shall provide higher-level off-grid SHS operation and maintenance services training followed up with annual refreshment trainings to at least 30 BPC technicians as focus persons to provide backup support to BPC's village technicians.

(II) Operation and Maintenance Services

2.5 The DOE shall mobilize the financial resources necessary for the operation and maintenance services of all solar home systems in off-grid villages.

2.6 The DOE shall provide 150 sets of SHS test, repair tools and instruments for use by BPC's village technicians and backstop technical support technicians.

2.7 The DOE shall identify specific SHS in off-grid villages to be served by BPC and develop with BPC SHS operation and maintenance service schedules to carry out SHS operation and maintenance services.

2.8 The DOE shall reimburse a fixed payment of Nu 500 per day to BPC's village technicians and applicable daily sustenance allowances of BPC to BPC's backstop technical support

personnel for all the travel expenses incurred and time spent on performing SHS operation and maintenance services requested by the DOE.

2.9 The DOE shall provide SHS operation and maintenance service forms (O&MSF) for BPC's village technicians and backstop technicians to record the actual SHS operation and maintenance services provided, parts replaced, and actual time spent as well the needs for spare parts. The DOE shall periodically verify the SHS operation and maintenance services performed and parts replaced by BPC's village technicians or backstop technicians,

2.10 The DOE shall reimburse on a bi-annual basis, according to the above Provisions 3.8 and 3.9, the expenses incurred by BPC after the receipt of the SHS operation and maintenance service records that have been fully verified and acceptable to the DOE.

2.11 The DOE shall provide SHS information flyers for BPC's personnel to communicate to SHS users about the SHS operation and maintenance services to be provided by the DOE and the cost of spare parts supplied by the DOE to be recovered from SHS users as their contribution.

(III) Procurement of Spare Parts

2.12 The DOE shall procure all the necessary spare parts and issue them to BPC for further issuance to SHS users.

2.13 The DOE shall maintain necessary funds for the retrieval and/or relocation of the SHS that are no longer required in light of other alternative electricity sources being made available.

(IV) Collection of Defective Batteries

2.14 The DOE shall reimburse the transport expenses of defective SHS batteries from off-grid villages to ESD offices at prevailing minimum wages established by the Government.

2.15 The DOE shall be responsible for collecting all the defective SHS batteries temporarily stored at ESD offices.

B. Responsibilities of the BPC

2.16 The Bhutan Power Cooperation shall assign its village technicians specific responsibilities for performing SHS operation and maintenance services as requested by the DOE to ensure all the solar home systems in off-grid villages will be functioning properly. As a minimum, BPC shall ensure that the following services are provided to the solar home systems requested by the DOE:

a. In the initial visit, train SHS users on the proper use of the SHS, and post the simple instructions sheet near the SHS set inside the house.

b. Check and provide monitoring, preventive and corrective measures three times a year or on a specific schedule requested by the DOE.

c. Preventive measures include checking and dusting of solar panels, checking controller, checking batteries, cleaning of battery terminals, topping of distilled water in batteries if applicable, and checking wirings and fuses; corrective measures include replacement of defective parts.

d. Respond to SHS user calls for emergency repair services.

e. Complete the SHS O&MSF including the services provided, the details of the spare parts used, new services or spare parts needed (if any), and total time (including travel time) spent, and have the form signed by the SHS user.

f. Collect payments for the spare parts as may be directed by the DOE, and issue receipts to the SHS users.

g. Arrange for the retrieval of defective batteries by local labor back to the nearest ESD offices to be handed over to the DOE.

h. Turn the completed SHS O&MSF and payments for spare parts collected from SHS users to Customer Service Center, and inform any additional services required and complex problems that could not be fixed.

2.17 The BPC shall provide the necessary technical backup support to the village technicians.

2.18 The BPC shall provide telephone numbers for SHS users to call for emergency repair services.

2.19 The BPC shall ensure that defective SHS batteries transported from off-grid villages are stored in protected areas before collection by the DOE.

2.20 The BPC shall provide timely information to the DOE covering (i) status and list of spare parts required by the SHS users for procurement, and (ii) amounts of defective batteries temporarily stored at ESD offices for collection by the DOE.

2.21 If the Government decides to charge a certain amount for the supply of spare parts, BPC shall deposit the charges so collected by village technicians to the specific account established by the DOE and send a deposit copy to the DOE for its records.

2.22 The BPC shall submit to the DOE monthly reports of (i) actual expenses (Nu 500 per day) incurred by its village technicians and (applicable daily sustenance allowances of BPC) by backup support personnel for providing SHS operation and maintenance services, (ii) actual

transport expenses of defective batteries from off-grid villages to ESD offices, and (iii) records of SHS operation and maintenance services provided by its village technicians and back up support personnel.

2.23 The BPC shall maintain separate accounts for off-grid SHS operation and maintenance services.

2.24 BPC shall ensure that no increase in the number of employees will result directly or indirectly from providing the off-grid village SHS operation and maintenance services.

SIGNATURES:

The provisions of this MoU have been discussed and agreed by the two parties on this __day of ______ 2010, in Thimphu, Bhutan.

Mr. Yeshi Wangdi Director General Department of Energy Ministry of Economic Affairs Thimphu	Signature: ______________________________ Date: _____________________________
Mr. Bharat Tamang Managing Director Bhutan Power Corporation Thimphu	Signature: -- Date: --

Appendix F
FINACIAL ANALYSIS

1. FINANCIAL ANALYSIS OF PROJECT COMPONENTS

1. **Methodology and Key Assumptions**. The financial analysis of the Project's proposed components was carried out in accordance with the Asian Development Bank's *Guideline on Financial Management and Analysis of Projects*.[42] The Project has four components: 1) on-grid rural electrification for 5,075 households, 2) installation of 1,896 solar home systems (SHS) in remote rural areas, 3) installation of 2x180 kW of grid-connected wind turbines as a pilot project, and 4) a pilot project to install 1,600 biogas units. The methodology involved cash flow projections for cost and benefit streams and comparing the resultant financial internal rate of return with the weighted average cost of capital. The key assumptions used were: 1) all cash flows are incremental, 2) all prices are at a constant mid-2010 price level, 3) projections are made over a 25-year period with no residual value at the end of 2030, and 4) O&M costs are assumed to be 2% of the original asset value, except for the pilot wind project, which is $10,000 per annum.

2. **On-grid Rural Electrification**. The specific assumptions used in the financial analysis of this component were: 1) incremental consumption at 75 kWh/month/household with an allowance of 5% to cover non-domestic consumption, 2) energy losses at 15% at the low-voltage level, 3) average rural tariff at Nu 1.12/kWh, and 4) average cost of energy purchases at Nu 1.20/kWh. Tariffs are determined by the Bhutan Electricity Authority (BEA) using the cost of supply methodology; tariffs are thereafter adjusted with the subsidy from royalty energy determined by the government. Tariffs are determined by voltage level.[43] The weighted average low-voltage domestic tariff is Nu 1.12/kWh and overall it is Nu 1.58/kWh. The average cost of supply is Nu 1.47/kWh and full cost recovery is achieved as a result of 75% of sales arising from 11 high-voltage customers. The average domestic bill amounts to Nu 64/month based on a consumption of 75 kWh/month. This is affordable, as it is 5% of the average monthly rural household income.

3. **Off-grid Solar Rural Electrification.** The specific assumptions used in the financial analysis of this component were: 1) a unit cost of Nu 26,995, including the solar battery at Nu 8,100, which will be replaced every five years, 2) annual maintenance cost at 2% of the capital

[42] ADB. 2005. *Financial Management and Analysis of Projects*. Manila.

[43] LV domestic tariff ranging from Nu 0.75/kWh to Nu 1.85/kWh. MV at Nu 155/kWh and HV at 1.55/kWh. MV and HV also include a demand charge of Nu 85 /kW/month.

cost, and 3) revenues will be savings in kerosene used for lighting, 4.7 liters/month at Nu 12.70/liter.

4. **Pilot Wind Component.** The specific assumptions for this component's financial analysis were: 1) installation of 2x180 kW turbines, and 2) average tariff for incremental energy at Nu 1.58/kWh, which is the average overall tariff.

5. **Pilot Biogas Component.** The specific assumptions used in the financial analysis of this component were: 1) a unit cost of Nu 26,000 for a $4m^3$ unit, 2) the electrification of the houses of the target clientele of dairy farmers, and 3) benefits are the cost savings from the displacement of firewood, LPG and electricity. The daily consumption of firewood, LPG and electricity is estimated at 12 kg, 0.22 kg and 4.1 kWh, respectively. It was assumed that biogas will reduce firewood and electricity consumption for cooking by 75% and LPG by 50%.[44] The current unit prices are 0 for firewood (it is freely collected), Nu 400 per 14 kg cylinder of LPG, and Nu 1.06/kWh for electricity. Another benefit from the use of biogas is that organic fertilizer is used as a byproduct and can be sold at Nu 11/kg – about 55 kg of fertilizer will be produced by a unit annually.

6. **Weighted Average Cost of Capital (WACC).** The capital costs of the on-grid RE, off-grid solar and pilot wind projects will be fully financed by ADB in the form of grant funds. Most of the government contribution will be in the form of staff and office facilities, which are in-kind contributions. Thus, the WACC is considered as zero. The biogas component will be partly financed by ADB in the form of a grant, a loan to the beneficiary at 10% per annum from BDFC, and the cost of the beneficiary's own contribution at a long-term deposit rate of 8% per annum. The WACC is therefore 0.2%.

7. **Financial Internal Rate of Return (FIRR).** Given that the rural domestic tariff does not achieve full cost recovery, the FIRR of the on-grid component is negative, although it will clearly have economic benefits. The off-grid solar RE component is aimed at electrifying those households in very remote areas where grid connection is only possible at an exorbitantly high cost. It is thus understandable that the FIRR is negative. The FIRR of the biogas component is 7.1%, which indicates that the project is financially viable as it exceeds the WACC. The financial net present value at a WACC of 0.2% amounts to Nu 42 million. The sensitivity analysis indicates that the FIRR still exceeds WACC where 1) costs increase by 10%, 2) revenues decrease by 10%, and 3) there is a delay of one year. Since the wind component is a pilot project aimed at demonstrating the potential of the wind resource towards energy security, the investment cost is provided as a grant to BPC. However, the pilot project will be financially sustainable, due to the free capital cost.

8. **Project Risks.** There are no major external risks envisaged in the Project. The electricity demand has been steadily growing and the risk of a lack of demand is minimal as the government has even planned for industrial load shedding in the coming years during the dry

[44] SNV. December 2009. *Feasibility Study of a Biogas Program in Bhutan*.

season. At the project level, there could be risk of price increases for civil works and equipment, and delays in project implementation. However, for the on-grid component and off-grid RE components, these risks are minimal as several previous rural electrification projects have been implemented efficiently and on time. Both the wind and biogas components are pilot projects. A market assessment of biogas in Bhutan indicates that there is good potential and the risk would be in the form of proper information dissemination to the dairy farmers and training of local masons. This risk will be mitigated to a large extent since these aspects will be supported by SNV, the Netherlands Development Organization, which has strong regional experience in the implementation of biogas programs and also has a track record of working for the target recipients of rural farmers in Bhutan.

2. FINANCIAL PERFORMANCE OF THE IMPLEMENTING AGENCIES

2.1 Bhutan Power Corporation (BPC)

9. **Historical Financial Performance.** The BPC is a government-owned utility and its mandate covers the construction and operation of electrical networks, sale of electricity within the country, and wheeling of electricity for export. It purchases power from the government-owned Druk Green Hydropower Corporation (DGPC) and sells power to its customers through its transmission and distribution network. The DGPC generates energy in excess of the domestic requirements and the BPC evacuates the surplus energy for export to India; wheeling charges are major revenue sources of the BPC. Overall, its financial performance over the period 2005-2009 has been satisfactory. The total revenue of the BPC grew by 32% during this period, which resulted in an annual average increase in profit of 14%. This is due to the over 30% per annum growth in electricity sales and wheeling revenues from exports. The BPC is entitled to purchase 15% of the total energy generated (except for a 1.2% allowance for auxiliary consumption), termed royalty energy, at a concessionary price of Nu 0.30/kWh. Any excess energy to meet the domestic requirement, i.e., on royalty energy, is purchased by the BPC at Nu 1.20/kWh.

10. The purpose of the royalty energy that the BPC purchases at a concessionary price is to ensure that a subsidized tariff is provided to the low-voltage customers, especially those consuming less than 300 kWh per month. At present, all payments for royalty and non-royalty energy are made by the BPC to DGPC. However, in future, royalty energy is expected to be paid by BPC to the Ministry of Finance.

Table F-1: BPC Historical Financial Performance (year ended 31 December)

Item	2005	2006	2007	2008	2009
Energy sales (GWh)	619	660	902	1,072	1,344
Energy wheeled by BPC (GWh)	1,777	2,027	4,533	5,922	5,405
Total revenue (Nu million)	928	1,132	1,785	2,389	2,858
Net profit / (Loss) (Nu million)	(130)	269	333	496	521

Table F-1: BPC Historical Financial Performance (year ended 31 December)					
Item	**2005**	**2006**	**2007**	**2008**	**2009**
Average yield (Nu/kWh)	1.04	1.20	1.31	1.46	1.56
Average cost of supply (Nu/kWh)	1.71	1.31	1.34	1.36	1.43
Cost recovery (%)	61%	92%	98%	107%	109%
Return on assets	-2%	4%	5%	7%	7%
Debt service coverage ratio	31.7	28.0	36.9	4.7	6.9
Debt equity ratio	15:85	16:84	24:76	21:79	21:79
Accounts receivable (days)	29	15	50	25	26

11. **Financial Projections.** Financial projections were made for the BPC (Table F-2) over a period of 10 years (2010 - 2019). The projection is based on the load forecast and the following assumptions: 1) domestic inflation to be 6% per annum throughout the period,[45] 2) total installed generation capacity to increase from 1,480 MW at present to 4,515 MW by 2019,[46] 3) load factor of the new hydropower schemes to be 50% (the existing load factors averages 70% for Kurichchu, 60% for Chukha and 50% for Tala), 4) overall commercial and technical line losses will remain at 7%, 5) wheeling revenue to remain at Nu 0.1111/kWh and royalty energy at Nu 0.13/kWh, 6) the present allocation for royalty and non-royalty energy to continue; 7) the tariffs for both retail and purchased power will be adjusted in such a manner that the resultant returns are within the rate of return determined by the BEA, and 8) capital expenditure program incorporated.

Table F-2: BPC Financial Projections					
Item	**2010**	**2012**	**2015**	**2018**	**2019**
Energy sales (GWh)	1,492	2,338	2,451	2,601	2,653
Energy wheeled by BPC (GWh)	5,248	4,354	9,898	12,843	17,098
Total revenue (Nu million)	3,078	4,470	5,403	6,131	6,746
Net profit / (Loss) (Nu million)	473	353	857	984	1,712
Average yield (Nu/kWh)	1.58	1.64	1.69	1.74	1.76
Average cost of supply (Nu/kWh)	1.47	1.60	1.60	1.68	1.51
Cost recovery (%)	108%	103%	106%	104%	117%
Return on assets	6%	5%	6%	4%	6%
Debt service coverage ratio	5.1	3.1	2.8	2.8	3.5
Debt equity ratio	29:71	39:61	46:54	46:54	43:57
Accounts receivable (days)	26	26	26	26	26

12. The projections indicate that BPC's profits will expand from 2015 with the addition of generating capacity as a result of both increased revenue from sales of electricity and wheeling charges. Due to additional generating capacity coming on stream starting in 2015, the BPC will

[45] International Monetary Fund.

[46] Construction of Punasangchchu I and Dagachchu have already commenced. Work on Punasangchchu II and Mangdechchu is expected to begin in 2010.

purchase a smaller amount of non-royalty energy from 2015 onward. The major increase in generating capacity is in 2015 with the commissioning of the Punatsangchchu I hydropower plant with a capacity of 1200 MW, thereby doubling the country's generation capacity. In 2013, the 114 MW Dagachhu hydropower plant is planned for commissioning, and in 2017 the 720 MW Mangedechchu hydro plants. By 2019, Punatsangchchu II (1000 MW) is expected to come on line, bringing the total hydropower generating capacity to 4,514 MW, up from 1,480 MW at present.

13. The results show that profitability is satisfactory throughout the period. The debt to equity ratio and debt service coverage ratio (DSCR) are satisfactory and are in compliance with the loan covenants under the previous Bank-funded rural electrification project. The covenants are a minimum DSCR of 1.5, a debt to equity ratio of 70:30, and an accounts receivable collection of less than two months.

2.2 Bhutan Development Finance Corporation (BDFC)

14. **Historical Financial Performance.** The BDFC is a government-owned financial institution established to cater to the needs of micro, small and medium enterprises with a special focus on agricultural development. Its financial performance has been satisfactory from 2005-2009 (Table F-3). Its non-performing loans (NPL) rate has improved significantly due to more stringent credit appraisal, supervision and monitoring, particularly in 2009. BDFC's average growth in the net profit was recorded at 18% per annum during the period as a result of its interest income and the growth in its loan portfolio. The loan portfolio increased by an annual average of 21% over the period 2005-2009. The average interest income on the portfolio has remained around 12%. Since the BDFC did not have a license to collect deposits from the public until March 2010, it financed its loan portfolio through borrowings. One source of financing to the BDFC has been loans from donors, which are on-lent by the government. The other source is borrowing from the domestic market, namely the commercial banks and the National Pension and Provident Fund. The average cost of borrowings has been about 5%, thereby giving the BDFC an interest spread of 7%.

Table F-3: BDFC Historical Financial Performance (year ended 31 December)

Item	2005	2006	2007	2008	2009
Loan portfolio (Nu million)	1,133.2	1,375.6	1,791.4	2,221.0	2,356.8
Total revenue (Nu million)	166.8	191.9	224.0	293.8	361.4
Net profit / (loss) (Nu million)	77.7	88.4	69.6	93.2	150.1
Interest spread (%)	8%	7%	6%	6%	7%
Return on assets	9%	9%	7%	8%	9%
Debt service coverage ratio	NA	1.6	1.5	1.0	1.9
Debt equity ratio	49:51	53:47	55:45	60:40	53:47
Statutory liquidity ratio	NA	18%	5%	13%	14%
Non-performing loans	20.4%	19.6%	21.3%	18.2%	13.6%

15. **Financial Projections.** Financial projections were made for the BDFC over a period of 10 years (2010 - 2019). The assumptions for the projections include 1) loan portfolio growth of 15% up to 2013 and 12% thereafter,[47] 2) average interest cost and interest income to remain unchanged from 2009 levels, 3) loan loss provisioning rates to remain unchanged,[48] 4) annual investments in fixed assets to be at 10% of total asset base, and 5) NPLs to reduce to 11% by 2011 (in accordance with RMA instructions) and to 9% by 2019.

16. Table F-4 presents a summary of the financial projections. The increase in customer deposits and repayment of long-term borrowings has resulted in DSCR improving to acceptable levels. The DSCR was reduced in 2018/19 from previous levels due to the repayment of debt. The BDFC will be able to supplement its deposits with additional borrowing if its loan portfolio needs to be expanded even further.

Table F-4: BDFC Financial Projections

Item	2010	2012	2015	2018	2019
Loan portfolio (Nu million)	2,948	3,908	5,642	7,876	8,802
Total revenue (Nu million)	412.3	544.1	783.4	1,099.3	1,230.8
Net profit / (loss) (Nu million)	196.8	249.6	418.3	637.6	743.8
Interest spread (%)	7%	7%	7%	7%	7%
Return on assets	10%	10%	11%	13%	14%
Debt service coverage ratio	1.5	2.1	2.7	1.7	1.6
Statutory liquidity ratio	15%	14%	13%	16%	18%
Non-performing loans	12%	11%	9%	9%	9%

3. FINANCIAL MANAGEMENT OF THE EXECUTING AND IMPLEMENTING AGENCIES

17. The financial management assessment of the EA (DOE), and the IAs (BPC, DOL and BDFC) was carried out. Financial management of these institutions is satisfactory. The DOE and the BPC have experience in four similar ADB-funded projects. The BDFC is currently implementing a Bank-funded project.

18. The DOE and the DOL are government departments, while the BDFC and the BPC are government corporations. All four institutions use computerized accounting systems. Both the DOE and DOL accounting systems capture expenditures by item and object code in line with the Government budget on a cash accounting basis. Both have a single officer initiating and recording transactions with the approval of a senior officer from the respective Ministry. The addition of another accounting officer will enhance internal control. The BPC and the BDFC

[47] BDFC's loan portfolio has increased by 21% in 2006, 30% in 2007, 24% in 2008 and 14% in 2009. With deposit funds being available from 2010, BDFC expects its portfolio to grow significantly.

[48] The mandate of BDFC's newly established credit risk division is to ensure that portfolio quality improves

have larger finance departments, are more commercial in orientation, and produce financial statements on an accrual basis. They have more complex accounting systems that are regularly updated with data from branches. The BPC is in the process of procuring integrated software for enterprise resources planning as the present Oracle-based system is time consuming for monthly accounting data uploading. The accounting system of the BDFC is updated online and in real time, although the payroll and asset management modules are not integrated.

19. The DOE and DOL are audited regularly by the Royal Audit. The BPC and the BDFC are audited by a private auditor and also by the Royal Audit Authority. The BDFC is also audited by the RMA. No material issues have been raised by the auditors and they have confirmed that these organizations maintain an adequate system of internal controls.

Appendix G
ECONOMIC ANALYSIS

1. BACKGROUND AND APPROACH

1. An economic analysis was undertaken to determine the economic viability of the Project. The analysis covers the Project's four components: 1) on-grid rural electrification, 2) off-grid rural electrification with solar home systems, 3) development of a grid-connected wind power pilot project, and 4) a biogas pilot project. The analysis comprised the evaluation of:

- National electricity demand forecast and households' demand for electricity
- least-cost plans for each component
- cost benefit analysis of the Project components.

2. Economic benefits will accrue from incremental energy consumption and the displacement of more expensive sources of energy. The incremental costs and benefits of subprojects were estimated by comparing "with project" and "without project" scenarios. The on-grid rural electrification component was analyzed on both a per-household basis and in aggregate, as were the off-grid RE with solar home systems, and biogas pilot project. The wind power generation component provides for the gathering of wind energy data and the development of a pilot project connected to the grid system.

2. DEMAND ANALYSIS AND FORECAST

3. **National Demand Forecast.** The growth in Bhutan's demand for electricity averaged 17% per year for the period 2005-2009 and was driven largely by high-voltage (HV) consumption, which grew at 23% per year. By the end of 2009, the Bhutan Power Corporation (BPC) had 91,268 customers out of which industrial clients in the HV category accounted for 73% of national consumption. The rapid growth of industrial consumption has exceeded Bhutan's existing capacity to supply electricity in the dry season. During the dry season Bhutan's generation capacity declines markedly and electricity supply is now being capped by shedding "industrial" loads and by the government limiting licenses for new industries. However, this approach has high economic costs, either by way of lost industrial production or by causing

industrialists to invest in captive diesel generation sets.[49] This supply-demand gap will grow until more new hydropower plants come on stream in the middle of the current decade. Energy sales to residential consumers are, however, not rationed and should continue to grow in line with improvements in the general populations' standard of living. Growth in residential demand, although a minor proportion of total consumption, will thereby account for the bulk of BPC's forecast 11% a year growth in energy sales.

4. **Household Demand and Affordability.** Over 95% of the electricity supplied by the on-grid rural electrification component will be consumed by households; the balance will be used by institutions and other consumers. Houses beyond the economic limit of the grid will be provided with solar home systems (SHS) that generate up to 2-3 kWh per month of electricity; this will be sufficient for three 3 watt white light emitting diodes (LED) and for charging cell phones. The impacts of electrification on rural households' demand for energy were evaluated and the results show that a grid-connected household purchases an average of 75 kWh per month of electricity and thereby obtain net benefits ("consumer surplus") of around 1,700 Nu per month by using electricity to replace more expensive forms of energy[50] and by increasing their overall energy consumption. The survey results and analyses of observed behavior (revealed preferences) confirm that the demand for access to electricity is substantial and affordable. Relatively poor rural households purchase rice cookers and other appliances even before they are connected to the grid. While SHS do not have the capacity to provide the same magnitude of benefits as a grid connection, they do provide households located beyond the reach of the grid the highly valued benefits of electric lighting and cell phone communications.

5. **Tariff and Subsidy.** There are significant cross subsidies within the electricity sector that are funded by the hydropower generators and embedded in BPC's retail tariff. The government's intention is to maintain the current lifeline tariff approach for residential consumers, and for a number of small and medium enterprises, but eliminate subsidies for HV consumers. The economic costs of low-voltage supply to residential consumers were close to 6 Nu per kWh in 2009 when all network and export opportunity costs are accounted for, compared with a tariff of 0.85 Nu per kWh[51] for consumption up to 100 kWh per month. The use of the electricity supply system to distribute economic benefits to rural consumers is considered well justified by the positive impacts of incremental electricity consumption on poverty alleviation, conservation of forests, and reduced use of fossil fuels. The high-voltage industrial customers currently receive approximately 40% of the total consumer subsidies that are delivered by the BPC. However the HV tariff has been steadily increased over time and the HV subsidies will be eliminated after 2011.

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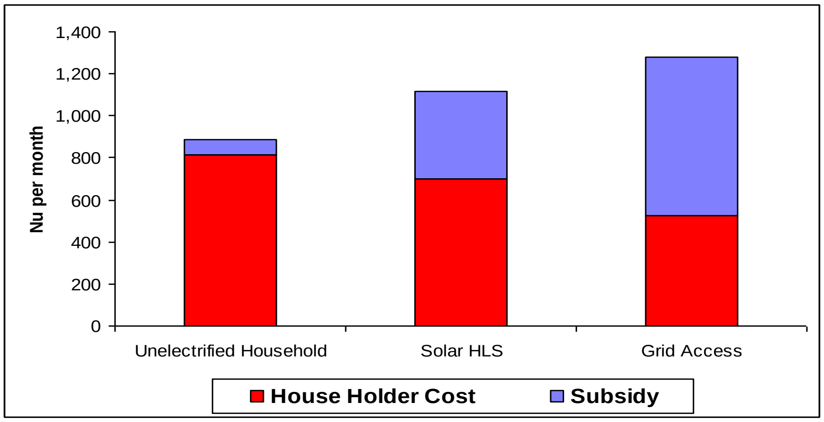
[49] Electricity produced by diesel gen sets costs Nu 17 per kWh or more under Bhutanese conditions. The Department of Energy is drafting a captive power generation policy.

[50] Candles, dry cell batteries and kerosene used by unelectrified households are highly expensive energy. Fuelwood is the main source of household energy, but the large quantities of fuelwood burnt in highly inefficient stoves off-sets its relatively low unit energy cost.

[51] From the tariff schedule approved August 2010 for the next three years.

6. Figure G-1 shows households' economic electricity costs and payments. The subsidy given to off-grid SHS users is only 55% of that provided to on-grid electrified customers; adequate subsidies sourced from the energy royalty would be justifiable to off-grid SHS users.

Figure G-1: Households' Economic Electricity Costs and Payments



3. LEAST-COST ANALYSIS, ECONOMIC BENEFITS, AND RISK ASSESSMENT

7. **Least-Cost Rural Electrification.** Bhutan's rural electrification program is based on providing electricity for all by 2013, using least-cost solutions for economically justified investment. The national Rural Electrification Master Plan prepared in 2005 assessed the economic limits for grid extension (the point at which the costs of any further grid extension would exceed the economic benefits). The economics of grid extension have subsequently been reviewed and detailed least-cost investment plans were updated during project preparation. Given that the proposed rural electrification program addresses "the last mile" of rural electrification, the BPC has opted to use telescopic poles and light single transformers to facilitate delivery and installation in remote areas. For households beyond the reach of the grid the provision of SHS is considered to be the only economic option and therefore the least-cost solution. The most likely "without project" options are small battery integrated diesel generators or micro hydro systems. Both of these "without" project options are problematic given the high costs imposed by isolation, difficulties of access, and low density of households. For mini/micro hydros, these difficulties would be exacerbated by the costs of developing suitable sites, the absence of technical support and assistance for O&M, the large variations in water flows between the dry and wet seasons, and the very low demand by households for power.

8. The objective of the wind power component is to pilot test the feasibility of diversifying Bhutan's generation, particularly during the dry season when hydropower generation capacity is much reduced by low river flows. The proposed pilot plant involves purchasing the smallest size grid-connected units that are available and is therefore the least-cost way to provide

Bhutan with practical experience in wind farm development and operation, including studies of impacts on the power supply system.

9. **Project Costs.** All costs and benefits are in constant 2010 second quarter prices with an allowance for physical contingencies. As foreign equipment is purchased on the international market, the estimated prices have been taken as indicative of their economic value. Capital cost estimates include physical contingencies, but exclude taxes, price contingencies and financial charges. The operating costs for the grid extension subprojects have been based on the BPC's experience. Projections of crude oil prices were used for establishing the value of petroleum fuels, such as kerosene and diesel that will be saved or consumed if electricity is unavailable.

10. **Net Benefits of Electrification.** Economic benefits of on-grid rural electrification are: 1) the incremental benefits to households of increased energy consumption, 2) Bhutan's cost savings from reduced consumption of kerosene, batteries, and fuelwood, and 3) the avoided costs of the "without project" option. In the increasingly remote areas that will be electrified by grid extension, the most likely "without project" option that would fulfill Bhutan's plans of providing electricity for all is SHS; they are considered avoided costs. Fuelwood is the largest single source of energy used by households and the savings in the costs of firewood collection have been monetized using a shadow wage rate of Nu 100 per day. Incremental benefits are the result of households' induced consumption of energy when they gain access to a lower-priced energy source, valued at their willingness to pay for incremental energy. The costs of providing grid access are: 1) the grid system investment and house wiring costs, 2) the incremental O&M costs of system investment, plus 3) the foregone returns from exports of electricity valued at the border price. The economic benefits of SHS are: 1) the cost savings from the avoided "without project" investment and 2) Bhutan's savings in the cost of kerosene and batteries.

11. **Benefits of Grid Connected Wind Power.** Bhutan's current inability to meet demand during the dry season has focused attention on possible hydropower options. The planned pilot project will assist in reducing the impacts of load shedding during the dry season and contribute to exports to India in the remainder of the year if any in the future. The economic cost of planned load shedding depends upon the structure and contribution of the affected sectors. The economic costs to industries of load shedding have been taken as being equivalent to the costs to industry of diesel-powered generation, on the order of Nu 17 per kWh. The electricity produced during the remainder of the year will have an economic value equivalent to the marginal export price. Besides supplying electricity to the national grid, the pilot project will provide Bhutan with insight and experience on the use of wind power, for possible larger-scale developments in the future.

12. **Benefits of Biogas Plants.** The biogas plants to be installed by dairy farmers produce a clean burning gas (75% methane) that is a substitute for fuels used in cooking. The saved fuel costs can include electricity, LPG, fuelwood, and kerosene, depending on the households' energy supply mix and consumption patterns. Additional benefits of biogas production include a reduction in emissions of methane (a potent greenhouse gas), improvements in peoples'

health from reduced indoor smoke from wood fires, production of fertilizer as a byproduct, and savings in labor incurred in collecting fuelwood.

4. CALCULATION OF ECONOMIC INTERNAL RATE OF RETURN AND SENSITIVITY ANALYSIS

13. **Estimated Economic Internal Rates of Return.** A period of 25 years was used for economic evaluation, with due allowance for residual values of long economic life assets. The results of the EIRRs for all components are summarized in Table G-1 and show that the Project and its key components are all projected to make a positive economic contribution.

Table G-1: Economic Internal Rate of Return Results

Component	EIRR
On-Grid rural electrification	12.7%
Off-Grid RE plus wind power	12.7%
Off-Grid RE with solar home systems	28.7%
Biogas pilot plant	14.3%
Aggregate all components	**13.9%**

Source: Asian Development Bank estimates.

14. The overall aggregate EIRR for the Project of 14% is dominated by the contribution of the on-grid rural electrification program, which accounts for the major portion of the overall Project investment. The impact of the wind power pilot on the grid component EIRR is by contrast negligible. The off-grid RE with SHS component has the highest overall EIRR, reflecting the benefits of lighting and cell phone communications that can be obtained by providing access to electricity using SHS, which are highly cost effective when compared with alternatives such as diesel power generators.

15. **Sensitivity and risk analyses.** The major risks faced by the Project have been tested by sensitivity analysis. The impact on economic returns of adverse impacts on the Project's costs and schedules, and on the realization of economic returns, is summarized in Table G-2.

Table G-2: Sensitivity Analysis

Item	Variable	EIRR
Base Case		13.9%
Project Cost	+10%	11.8%
Benefits	-10%	11.6%
Time Period	+ 1 year	11.4%

Source: Asian Development Bank estimates.

16. The sensitivity analysis shows that returns are acceptable under adverse circumstances with aggregate returns close to the economic hurdle rate of 12%. The returns are most sensitive to time delays on Project completion, especially for the on-grid extension component. However, the likelihood of delay is low, given that BPC is continuously working on rural electrification and can readily deploy experienced people and quickly mobilize other available resources.

17. **Economics of On-Grid Electrification.** The detailed costs and benefits of the on grid extension and the economic cost-benefit calculation are presented in the Table G-3.

Table G-3: Economic Internal Rate of Return Calculation for Grid Extension ($ million)

Year	Benefits		Costs			
	Incremental Consumption	Cost Savings	Capital	O&M	Supply	Net Benefits
2011	0.13	0.05	1.90	0.00	0.01	(1.73)
2012	0.72	0.29	7.60	0.04	0.08	(6.69)
2013	1.58	0.64	7.60	0.18	0.17	(5.73)
2014	1.98	0.81	0.95	0.33	0.21	1.30
2015	2.09	0.85	0.95	0.35	0.22	1.42
2016	2.13	0.87	0.00	0.36	0.23	2.41
2017	2.13	0.87	0.00	0.36	0.23	2.41
2018	2.13	0.87	0.00	0.36	0.23	2.41
2019	2.13	0.87	0.00	0.36	0.23	2.41
2020	2.13	0.87	0.00	0.36	0.23	2.41
2021	2.13	0.87	0.00	0.46	0.23	2.32
2022	2.13	0.87	0.00	0.73	0.23	2.04
2023	2.13	0.87	0.00	0.73	0.23	2.04
2024	2.13	0.87	0.00	0.41	0.23	2.36
2025	2.13	0.87	0.00	0.41	0.23	2.36
2026	2.13	0.87	0.00	0.36	0.23	2.41
2027	2.13	0.87	0.00	0.36	0.23	2.41
2028	2.13	0.87	0.00	0.36	0.23	2.41
2029	2.13	0.87	0.00	0.36	0.23	2.41
2030	2.13	0.87	0.00	0.36	0.23	2.41
2031	2.13	0.87	0.00	0.46	0.23	2.32
2032	2.13	0.87	0.00	0.73	0.23	2.04
2033	2.13	0.87	0.00	0.73	0.23	2.04
2034	2.13	0.87	0.00	0.41	0.23	2.36
2035	2.13	0.87	0.00	0.41	0.23	2.36
					EIRR	**12.7%**

18. The detailed breakdown shows the significant contribution of incremental consumption to economic welfare, which is a direct benefit that is captured by rural households when they are connected to the grid and can make good use of the lifeline tariff to meet their basic needs.

5. ASSUMPTIONS FOR THE ECONOMIC ANALYSIS

19. An economic analysis was carried out in accordance with the Asian Development Bank's *Guidelines for the Economic Analysis of Projects* and the ERD's Technical Note No 3 "Measuring Willingness to Pay for Electricity." The Project comprises: 1) on-grid connections for 5,075 rural households, 3) installation of 1,896 solar home systems (SHS) in remote rural areas, 4) a wind power pilot project with an installation of 2x180kW of grid-connected wind turbines, and 4) a pilot biogas project to install 1,600 biogas plants. The approach involved the identification of each component's least-cost solution and economic cost / benefit analyses. Economic returns were calculated by discounting Bhutan's projected net benefits (cost savings and benefits of incremental consumption less costs) at 1a 2% per year economic cost of capital. Key assumptions are: 1) net benefit flows are computed by comparing the with and without project situations, 2) costs and benefits are valued at constant mid-2010 border values, 3) projections are for 25 years, 4) O&M costs are 2% of the original asset value, except for the pilot wind project which is $10,000 per annum, and 5) electrification of rural households has the impacts detailed in Table G-4:

Table G-4: Economic Impacts of Rural Household Electrification

Household Energy Consumption - Per Month									Expenditure
Energy Source		Consumption	Unit	Unit Cost	Energy Content	Conversion Efficiency 1/	Energy Benefit (Q)	Effective Cost (P)	Nu / Month
		Units / Month		Nu / Unit	kWh / Unit	%	kWheq / Month	Nu / kWheq	
Unelectrified Household	Firewood	600	kg	1.1	4.00	0.60%	14.4	45.8	660
	Kerosene	4.7	litre	12.7	10.00	0.47%	0.2	273.0	60
	Dry Cell Battery	5.3	No	17.7	0.003	23.3%	0.00	24,938	93
	Total						**14.6**	**55.6**	**813**
With Grid Connection	Firewood	388	kg	1.1	4.00	0.60%	9.3	45.8	427
	Kerosene	1.4	liter	12.7	10.00	0.47%	0.1	273.0	17
	Dry Cell Battery	0.8	No	17.7	0.003	23.3%	0.001	24,938	14
	Grid Electricity	78.8	kWh	0.85	1.00	54.4%	42.9	1.6	67
	Total						**52.3**	**10.1**	**525**
With SHS	Firewood	600	kg	1.1	4.00	0.60%	14.4	45.8	660
	Kerosene	1.4	liter	12.7	10.00	0.47%	0.1	273.0	17
	Dry Cell Battery	0.8	No	17.7	0.003	23.3%	0.001	24,938	14
	PV Electricity	1.0	SHLS	10.00	1.53	90.7%	1.4	7.2	10
	Total						**15.9**	**44.2**	**701**

20. **On-grid Rural Electrification**. The specific assumptions were: 1) electricity consumption averages 78.8 kWh/month/household, 2) technical losses of electrical energy reach 15%, 3) the economic value of electricity is Nu 1.89/kWh (current export return at the Indian border), and 4) the cost of grid connections averages $3,593 per household inclusive of house wiring.

21. **Off-grid Solar Rural Electrification.** The specific assumptions were: 1) SHS unit cost of Nu 26,995, including battery (Nu 8,100), which is replaced every five years, 2) annual maintenance cost is 2% of capital cost, and 3) benefits are savings in kerosene and dry cell batteries (Table G-4), and improved lighting and cell phone charging capability.

22. **Pilot Wind Component.** The specific assumptions were: 1) installation of 2 x 180 kW turbines, 2) benefits of the incremental output are reduced industrial load shedding in the dry season at the cost of diesel generation (Nu 17 per kWh) and increased exports in the remainder of the year.

23. **Pilot Biogas Component.** The assumptions were the same as those used in the financial analysis, with the following adjustments to economic values: 1) labor savings valued at the minimum wage of 100 Nu per day and 2) savings in kerosene, electricity and LPG at their border (import / export) value.

Appendix H

INITIAL ENVIRONMENTAL EXAMINATION FOR THE OFF-GRID SOLAR HOME RURAL ELECTRIFICATION COMPONENT

1. EXECUTIVE SUMMARY

1. **Need for the Project.** Bhutan is a mountainous country and rural electrification through the grid is not possible at many remote isolated rural habitations for techno-economic reasons. The RGOB has set a target of Electricity for All by 2013. To achieve this target, solar home systems (SHS) will be installed for households in remote isolated villages where grid extension is not feasible.

2. **Objectives.** The objectives of Project are to provide electrification in rural households where extension of grid is not possible. The SHS project aims to provide rural electrification in 1,896 households in 10 dzongkhags: Chukha, Dagana, Gasa, Haa, Paro, Punakha, Samtse, Sarpang, Trongsa, and Wangdue Phodrang.

3. **Project Targets.** The SHS project will be spread over 10 dzongkhags of the country. The number of households targeted for each dzongkhag is shown in Table H-1:

Table H-1: Households Targeted for SHS by dzongkhag

S. No.	Name of dzongkhag	Targeted Number of Households
1	Chukha	563
2	Dagana	231
3	Gasa	188
4	Haa	170
5	Paro	44
6	Punakha	16
7	Samtse	177
8	Sarpang	177
9	Trongsa	70
10	Wangduephodrang	260
	Total	1,896

4. **Initial Environmental Examination (IEE).** The IEE was included during project preparation to streamline environmental issues in SHS project implementation. The IEE report was prepared

in accordance with ADB's *Safeguard Policy Statement 2009*. The IEE preparation led to identification of potential environmental impacts during the construction and operation phases and the preparation of an Environmental Management Plan (EMP) to mitigate the identified impacts.

5. **Category of the Project**. The SHS project has been categorized as Category B because there are no significant adverse impacts during the installation and operation phases.

6. **Brief Details of the Project.** The specifications for the proposed solar home systems to be installed take into account the transport costs to the remote mountainous areas and the improved system reliability to reduce maintenance requirements.

Table H-2: System Components and Specifications

S. No.	Component	Specifications
1	Solar Panel	50 WP
2	Charge Controller	7 Amps
3	Luminaries	3 x 3 Watt WLED
4	Battery	50 AH@ c20, <32 kg
5	Night Lights	2 x 0.5 Watt LED
6	Mobile phone charge	Socket & cable
7	Wires	As available
8	Accessories	As available

7. The project design reflects the weather conditions, solar insolation resources, cable losses, pane degradation factors, battery and charge controller efficiencies, and aging of components over time in Bhutan.

8. **Implementing and Executing Agencies.** The Department of Energy (Ministry of Economic Affairs) will be the Executing Agency (EA), and Department of Energy's (DOE) Renewable Energy Division (RED) will be the Implementing Agency (IA) for installation of SHS sets. The RED has managed the implementation of the Bhutan Solar Electrification Program since 2006; during this time, it has performed well in managing solar home electrification projects.

9. **Policy, Legal and Administrative Framework.** In Bhutan environmental protection has been entrusted to the National Environment Commission (NEC). The Royal Government of Bhutan has enacted a number of acts and rules such as the Forest and Nature Conservation Act 1995, and Forest and Nature Conservation Rules 2000. The SHS project does not require environmental clearance as this has not been included in the list of industries/activities requiring environmental clearance. But on the advice of the NEC, an application for environmental clearance was prepared and submitted to the NEC. An environmental clearance exemption was subsequently granted by the NEC.

1.1 Description of the Environment

Physical Environment

The determination of the baseline conditions is a pre-requirement in the preparation of IEE reports. The prevailing baseline conditions in the project areas are described below:

10. **Topography, Geography and Soils.** All ten dzongkhags where SHS are planned lie in the central, northern and western parts of the country with elevations ranging from 200 m to 5,600 m above sea level. Parts of Haa have the highest elevation, at 5600 m. In these higher zones installation is not likely as there are no habitations.

11. All ten dzongkhags fall within the Lesser Himalayan formation. This includes a wide range of sedimentary and low-grade metamorphic rocks, including argillites and metargillites, sandstones and quartzites, limestone, dolomite and gypsum. Gneisses underlie more than 70% of the country, and range almost to the Indian border. Shumar and Manas formations also exist in some of dzongkhags such as Sarpang. The Shumar formation comprises alternating sequences of quartzite.

12. The soil types found in all 10 dzongkhags range from sandy, clay, loam to sandy loam and clayey loam. Generally the soil in the alluvial lowland river valleys is quite fertile and crops grow well as soil moisture is also adequate in the foothills. At lower altitudes, many of the slopes are covered with colluviums, a mixture of soil and stones deposited by slow creep and many small landslips and slumps. On the slopes, soils are shallow.

13. **Climate.** The climate in the project areas varies according to altitude. The higher altitudes experience cool temperatures with warm humid summers and chilly winters with snowfall in some parts in winter, while in the lower elevation areas the climate is sub-tropical to temperate. The Wangduephodrang dzongkhag has strong winds that blow across the valley frequently.

14. The relative humidity in the project areas ranges from 63% to 90%, with an average of about 70% in the past four years. The least-humid period is during the pre monsoon (March-May). The average mean temperature for the warmest months of June and July is about 20-30° C, while the mean temperature for the coldest months of January and February is about 10-12° C. In January and December, temperatures higher-altitude locations such as Gasa drop to minus 2° C.

15. The average annual rainfall ranges from 600 mm to 5,000 mm, but sometimes the precipitation becomes much heavier. Precipitation is heaviest between June and September.

16. **Ambient Air Quality.** Ambient air quality monitoring is not being done in the project

areas. The NEC is monitoring air quality at Phuentsholing and Thimphu only. The concentrations of inhalable particulates and gaseous pollutants at both locations are within the limits. In the project areas, ambient air quality is expected to be better as there are less pollution-generating traffic and commercial activities.

17. **Surface Water Resource and Quality.** Each dzongkhag has perennial rivers and local streams that drain the area. The prominent streams are Maokhola, Shetikhahray Chu and Dawalakhola Chu in Sarpang, Wong Chu in Chukha, Paro Chu in Paro, Phegu Chu, Tong Chu, Pho Chu, Mochu and Punatangs Chu in Gasa, Tsang Chu, Dang Chu, Kisona Chu and Hangra Chu in Wangduephodrang, Pho Chu, Mochu, and Sankosh Chu in Punakha. Tributaries of Wong Chu also drain Haa. Wong Chu tributaries drain Dagana and Trongsa by the river system mentioned for Wangdue. Samtse dzongkhag is drained by Torsa River.

18. **Groundwater Resource and Quality.** There are no data available on the groundwater resource. Groundwater resources are also abundant with springs emerging from underground rocks, old landslides and fluvial deposits. Groundwater in landslide and alluvial deposits has been estimated at an exploitable rate of 3 liters/second/km^2. Currently water quality monitoring is only conducted in the four major river systems of Bhutan. Generally, Bhutan's groundwater quality is good, but with expanding settlement along rivers, there are localized pollution problems. In the project areas, water quality is anticipated to be good.

19. **Noise.** Data on measured ambient noise levels are not available in the project areas as the NEC is currently measuring noise levels at Phuentsholing and Thimphu only. Major contributors to the ambient noise levels are commercial activities and vehicular traffic. There are few commercial or vehicular activities in project area; therefore, ambient noise is expected to be within the ambient noise standards set by the NEC for rural and residential areas (55 dB(A) during the day, and 45 dB(A) during the night.

20. **Aquatic Environment.** There are 41 known species of fish in the rivers and lakes of Bhutan. This includes eight exotic species like the coldwater trout, and seven species introduced for warm water aquaculture.

Ecological Resources

21. **Protected Areas.** In ten dzongkhags where SHS projects are planned, there are six protected areas: Jigme Singye Wangchuk National Park (JSWNP), Royal Manas National Park (RMNP), Phibsoo Wildlife Sanctuary (PWLS), Torsa Strict Nature Reserve (TSNR), Blue Mountain National Park (BMNP), and Jigme Dorjee National Park (JDNP). These protected areas fall in Sarpang, Dagana, Paro, Haa, Wangdue Phodrang, Trongsa, Gasa and Punakha. dzongkhags. SHS sets are to be installed in the houses of villagers, so no adverse impacts on the protected areas are anticipated.

22. **Forest and Flora.** The dominant forest type in all 10 dzongkhags is broadleaf, representing 30% to 95% of the forest areas. The second dominant category of forest is mixed

conifer. The forests in the protected areas mainly comprise subtropical forests, warm broadleaved forests, and cool broadleaved forests.

23. **Wildlife.** Wildlife has been reported in forest areas. There are 76 species of fauna found in the forests of the project areas. The installation of SHS will only be in the houses where no wildlife is expected.

Economic Development

24. **Land Use, Industries and Agriculture.** The predominant land use in the project areas is forest. Each dzongkhag has an average of 60% forest area except Chukha and Dagana where forest area percentages are 82 and 80, respectively. The cultivable area is less than 8% in all ten dzongkhags. The percentage of the area under settlement is about 0.3% (the country's population density is only 16 persons per square km). The area under pastures is around 4%. The balance land uses is in water bodies and rocky areas.

25. Major crops produced in the project areas include maize, wheat, buckwheat, barley, mustard, finger millet and foxtail millet, along with a wide variety of green vegetables. Potato producing areas are Haa and Paro. While oranges are grown in almost all of the southern dzongkhags, cardamom, areca nut, ginger, guava, lemon, banana and mango are also grown extensively in plain areas close to the Indian border.

26. Most of the existing industrial establishments in Bhutan are small-scale or cottage industries. In the project areas there are industries in Samtse, Sarpang and Chukha. Phuentsholing, the biggest industrial area is located in Chukha. There is good growth potential for industries in Gelephu. A new airport is planned at Gelephu. Two major hydropower projects owned by Chukha Hydro Power Ltd. and Tala Hydro Power Ltd. are located in Chukha dzongkhag.

Administrative Infrastructure and Community Facilities

27. All dzongkhag headquarters in the project area (Sarpang, Chukha, Damphu (headquarters of Samtse), Dagana, Gasa, Paro, Haa, Punakha, Trongsa and Wangduephodrang) have dzongkhag administrative offices such as forest, revenue, and courthouse. These also have amenities such as banks, post offices and communication centers.

28. Community facilities such as schools and health clinics exist at the gewog and dzongkhag levels. Almost 50% of the population has access to piped water supply.

29. **Transportation.** Transportation facilities in all dzongkhags are roads and mule tracks. Remote locations at high elevations are connected through mule track. The country's only international airport is at Paro in Paro dzongkhag. There is no railroad in any of the dzongkhags. One airport is proposed at Gelephu in Sarpang dzongkhag.

30. **Electricity and Communication.** The households close to dzongkhag headquarters have been electrified through grid extension. Based on the information available on dzongkhag websites, the numbers of households electrified are 1,563 in Samtse, 2,197 in Sarpang, 10,323 in Chukha, and 1,490 in Wangduephodrang. In other dzongkhags the exact number of households electrified is not known, but overall electrification is around 70%.

31. All dzongkhag headquarters are connected by line telephones. All dzongkhag towns have mobile phone connectivity.

32. **Tourism.** The majority of tourists visit the dzongkhags where tourist attractions exist such as Paro, Punuakha, and Wangduephodrang. These dzongkhags account for over 77% of the total number of guest houses and hotel facilities in Bhutan. The remaining seven dzongkhags have very poor tourism potential due to their poor infrastructure facilities.

33. Gasa is also a popular trekking destination because it has a number of trekking routes, such as the 24-day snowman trek in Lunana, and the 2-week Lingshi-Laya-Gasa trek starting from Paro and ending in Punakha, the Gasa-Laya trek, and the 2-week Masagang trek.

Social and Cultural Resources

34. **Demography.** The population of Bhutan includes many ethnic groups such as the Sharchops in the east, Ngalongs in the west, Khengpas in the central region, nomads in the north, and Lhotshampas in the south. These (and others) are all found in the project areas. Because of the mix of ethnicities a wide variety of dialects are spoken, of which Dzongkha, Khengkha, Sharchop and various dialects of Nepali are the most common. The majority of the population is Buddhist (around 70%) and the remainders are mainly Hindu, mostly in the southern areas.

35. The project areas have a sex (male to female) ratio of 1:1. In the project areas about 70% of the population is rural residents while 30% are urban dwellers. The average number of family members per household is 4.7 in the project areas. The employment rate is about 40%. Around 79% of the households in the dzongkhags own land, 59% own their home, 8% own their own business and 15% own a vehicle.

36. **History and Culture.** There are a few culturally important monasteries and other important culture structures in Wanagdue, Punakha and Paro.

37. In Bhutan traditions are followed religiously. The men and women wear their traditional dress Kho and Kira, respectively. In the project areas, traditional dress is worn. In Gasa dzongkhag Layaps (from Laya) and Lunaps (from Lunana) are unique because they have their own dress, language, culture and tradition.

1.2 Environmental Impacts and Mitigation Measures

38. No impacts during construction and operation have been identified on the ecologically-sensitive and protected areas of the project areas such as JSWNP, RMNP, BMNP, JDNP, TSNR, or PWLS. The other environmental attributes where no impacts have been identified during construction and operation are:

- Physical Resources - Geology, climate, ambient air quality, surface water sources and quality, groundwater sources and quality and noise levels, rural services/utilities (water supply, electricity, and telephone lines, etc.)
- Ecological Resources - Rare and endangered species, wildlife, and biodiversity.
- Economic Development Resources - Land use, industries, agriculture, tourism, transportation, electricity and communication, and administrative infrastructure
- Social and Cultural Resources **-** Demography, history and culture, involuntary resettlement.

39. The only impact identified on topography is that the PV panels of SHS will be visible. This will be permanent impact and will start from the installation phase.

40. The other impact identified during the operation phase is the collection of used batteries. If the batteries are disposed off in open land, then they will contaminate the soil with lead, a poisonous heavy metal.

41. No adverse impact has been identified on the biodiversity of the project areas.

42. Bhutan Power Corporation (BPC) is operating about 150 Customer Service Centers at the village level in Bhutan. The implementing agency of the SHS project is the Renewable Energy Division (RED) of the DOE. The DOE will outsource operation and maintenance of SHS sets to the BPC to be performed by BPC's contracted village technicians. If a battery is not working and has to be replaced, the village technician will arrange local labor to carry the used battery to BPC's nearest customer service center. The DOE SHS O&M manger will arrange a truck to pick up used batteries from BPC's customer service centers periodically. These batteries will be transported to Phuentsholing. Thereafter, they will be turned over to authorized battery recyclers in India. A leak-proof used battery collection system will be developed. Hence no impacts are anticipated on soils and the environment of the project areas.

43. Since minor visible changes in topography are permanent but not aesthetically unpleasant, no mitigations are warranted for this.

44. The proposed SHS project will use solar energy for lighting and mobile phone charging in rural households. Solar energy is a clean, sustainable and renewable energy. The project will have a host of environmental and social benefits, including:

- Use of clean and sustainable solar energy
- Reduction in kerosene and candle consumption for lighting
- Reduction in greenhouse gas emissions as a consequence of reductions in kerosene consumption
- No social issues and no cutting of trees
- Cost effective
- Direct and indirect employment opportunities
- No loss of energy in the transmission network.

1.3 Analysis of Alternatives

45. Three possible alternatives have been considered. They are summarized and compared in Table H-3.

Table H-3: Comparison of Alternatives

Parameters	**No Project Scenario**	**Project Scenario**	**Other Form of Energy (Micro Hydro)**
Economic cost	Use of kerosene/candles is financially very cheap.	SHS will cost about Nu 27,000 The RGOB is installing the SHS free of charge, but during the operation phase there will be a charge of 10% of the spare part costs from the owners of SHS system	High cost and perhaps not feasible to install due to terrain and techno-economic reasons Will take a long time to finalize proper locations and targets of electrification will not be achieved on time No reliable power supply in winter due to reduced water flows
Developmental impacts & people's perceptions	Village/gewog considered underdeveloped	Community will be considered developed	Community will be considered developed
Social benefits	The lighting quality is poor from kerosene or candles lamps. This poor lighting will cause problems for those working and studying	Clean and renewable energy The lighting quality will be good for studying and other domestic activities It can be installed anywhere without a problem No significant recurring cost to	Hydropower is also clean energy. During the winter, low river flows preclude adequate functioning Electricity supply at many villages is not possible due to the difficulty in extending distribution lines in difficult terrain

Table H-3: Comparison of Alternatives			
Parameters	**No Project Scenario**	**Project Scenario**	**Other Form of Energy (Micro Hydro)**
		households as O&M will be subsidized	
Environmental impacts	There will be continued impacts due to emissions of greenhouse gases from burning fossil fuels, which will have negative impacts on the environment	No adverse environmental impacts Greenhouse gas emissions will be reduced Effective and leak-proof collection of used batteries planned	Extending distribution lines will involve cutting trees in the grid's right of way. This will have negative impacts on forests. In some situations extending distribution lines from small hydro may not be possible due to difficult terrain.
Health	Negative impact on health due to smoke generation	Positive impact on health as solar energy is a clean form of energy	Positive impact on health

46. Based on the above comparison, the project alternative is the best alternative for achieving the target of the RGOB for 100 % electrification of all households by 2013. The project alternative from the environmental perspective is also good.

1.4 Public Consultations and Information Disclosure

47. Public consultations have been carried out since inception stage of the project to disseminate information on the project. The consultations were carried out at the institutional, local, and dzongkhag levels.

Table H-4: Summary of Public Consultations				
S. No.	**Date of Consultation**	**Level**	**Organizations/ Rural Locations**	**Objective**
01	03-12-2009	Inception workshop by PPTA consultants	NEC,BPC, Ministry of Agriculture and Forests, Ministry of Economic Affairs, JICA, ADB	Objective of workshop was to solicit views, comments and suggestions on the Project
02	08-12-2009	Institutional	NEC for environmental clearance of SHS project	Director at the NEC suggested submitting concept papers for each component
03	17-12-2009 and 26-03-2010	Dzongkhag level	Consultations with Chukha district head and local public at Chukha for SHS installations.	To inform participants of the planned SHS installations and receive enquiries from the public and suggestions

Table H-4: Summary of Public Consultations				
S. No.	**Date of Consultation**	**Level**	**Organizations/ Rural Locations**	**Objective**
				from the dzongkhag head
04	12-01-2010	Local level	Dobang Gewog in Sarpang dzongkhag	To inform the public about the project and to invite their comments and suggestions
05	15-01-2010	Local level	Chhota Tsirang /Sisty village in Sarpang dzongkhag	To inform the public about the project and to invite their comments and suggestions
06	19-01-2010	Local level	Tongshto Village in Tseza Gewog in Dagana dzongkhag	To inform the public about the project and to invite their comments and suggestions
07	23-01-2010	Local level	Thasa village in Lajab Gewog in Dagana dzongkhag	To inform the public about the project and to invite their comments and suggestions
08	28-01-2010	Local level	Upper Majgaon village in Patalay Gewog in Tsirang dzongkhag	To inform the public about the project and to invite their comments and suggestions
10	28-01-2010	Local level	Tsakling	To inform the public about the project and to invite their comments and suggestions

48. The public's comments, suggestions and concerns, responses made in the consultations are summarized below:

Table H-5: Summary of Responses to the Issues or Concerns of the Public	
Issue/Concern Raised	**Responses/Comments Provided**
There are clouds most of the year; thus, functioning may be difficult (issue raised at Dagana)	Available solar insolation (solar radiation) data for Dagana dzongkhag indicated that available solar insolation is sufficient for an effective operation of SHS
Electricity supply through grid is preferred as it will be more reliable (Issue raised at most locations)	Consultants explained to the villagers that extension of grid is not possible due to techno-economic reasons.
SHS batteries will be costly and difficult to transport to villages when replacements are required	The installation of new SHS will be free of cost. The battery life is 3-5 years. The subsequent battery replacement will be made available at subsidized rates (only 10% of the costs of spare parts will be charged by the DOE). O&M will be provided by BPC's

Table H-5: Summary of Responses to the Issues or Concerns of the Public	
Issue/Concern Raised	**Responses/Comments Provided**
	village technicians, who will arrange for a labourer to pick up the used battery and take it to the nearest BPC customer service center.
O&M will be a problem for locals as they have neither experience nor have seen any SHS working	O&M will be provided by BPC's contracted village technicians. At the Renewable Energy Department (RED) there will be a full time operation and maintenance manager who will manage O&M of the SHS project with the help of BPC.
Disposal of old batteries and taking care of PV panels will be a problem	Village technicians will replace the old batteries with new ones. The old batteries will be taken to the closest BPC customer service center. From there, the RED SHS O&M manager will arrange for their transportation to Phuentsholing, and then to India for recycling.
Some people were apprehensive that defective, non-working SHS may be provided	DOE will procure all SHS with good technical specifications established and from a known manufacturer under warranty. The question of defective SHS does not arise.

49. At institutional level consultations, all the participants have welcomed the project as this project will provide clean energy and help achieve the target of 100 % electrification by 2013.

1.5 Grievance Redress Mechanisms

50. The SHS project does not involve any acquisition of land and there is no generation of emissions, effluents or solid waste. Public complaints on environmental impacts are not anticipated as SHS will be installed in private homes. The DOE will sign a MOU with the BPC for the O&M of SHS in the post-installation phase. Currently the BPC has 150 customer service centers across the country. All O&M complaints will be received at these Centers. After receiving a complaint, a village technician must resolve the problem within seven 7 working days. Complaints will also be forwarded to the RED's dedicated SHS O&M Program Manager. This manager will be the focal person to resolve any grievances within two weeks. However, no complaints related to the environment are anticipated. However, in the event that complaints arise, the O&M SHS program manager will address them. This manager will also be responsible for the EMP implementation. The RED will follow an open door policy to receive any suggestions to improve the functioning of SHS. These suggestions will also be received at Customer Service Centers and the office of SHS at the RED.

1.6 Environmental Management Plan (EMP)

51. The Environmental Management Plan includes measures for mitigating potential negative impacts. For each mitigating measure to be taken, its location, timeframe, implementation and oversight/supervisory responsibilities are to be noted in the EMP.

52. There is no exclusive EMP cost, as this has been included in the other project implementation costs.

1.7 Findings, Recommendations, and Conclusion

Findings

53. The findings of the IEE are as follows:

- The SHS project is environmentally friendly and it will help achieve the RGOB target of electricity for all by 2013. It will help electrify households in remote isolated areas where grid extension is not possible.

- The potential environmental impact identified is related to the collection and transport of used batteries from the BPC customer service centers. For this an EMP has been prepared. There will be no short- or long-term adverse impacts on the environment during the installation and operating phases.

- The quality of life of the rural population will improve and the project will bring prosperity. There will be direct and indirect generation of employment due to the project's implementation.

- Mitigation and monitoring measures have been developed in the EMP. The EMP will be implemented by the O&M program manager at the RED, and monitored and enforced by relevant regulatory agencies and ADB. Public consultations have been undertaken during the project's preparation. The RED will have an open door policy for receiving complaints and will conduct additional consultations as necessary during project implementation.

Recommendations

54. The DOE will select an agency through competitive bidding for the leak-proof collection of used batteries from BPC customer service centers and for transporting these batteries to Phuentsholing and then to authorized battery recyclers in India.

55. A memorandum of understanding should be signed between the BPC and the DOE for SHS O&M by the BPC village technicians

56. Village technicians will be trained on preventive and corrective maintenance of SHS and safe transport of used batteries. A similar training program is needed during the operating phase for selected transporters who collect and move used batteries.

Conclusion

57. The SHS project will not result in any long-term significant adverse impacts. The likely negative impacts will be avoided through the safe collection of used batteries. Environmental and social benefits of the project and long-term investment program objectives outweigh the potential negative impacts.

58. Based on the environmental assessment activities conducted to date, the project is classified as environmental category B. The IEE, including the EMP, is considered sufficient to meet the environmental assessment requirements of the ADB and RGOB. A full environmental impact assessment study is not required.

2. BACKGROUND

59. Bhutan is a mountainous country with settlements scattered over numerous mountains and valleys. Most settlements are cut off by steep slopes and forests, making the delivery of basic services such as electricity and telecommunications economically very inefficient. The RGOB intends to provide electricity to all by 2013. Due to terrain and topographic conditions, providing electricity to remote rural household and institutions through grid extensions is not possible. To achieve its objective, the RGOB will install solar home systems (SHS) for 1,896 households under assistance from an ADB grant. All installations will be in the remote rural areas where more than 90% of the country's poor live. All SHS will be installed in villages where electricity cannot to be supplied through on-grid electrification for techno-economic reasons. The dzongkhags selected under the ADB grant assistance for SHS installations are Chukha, Dagana, Gasa, Haa, Paro, Punakha, Samtse, Sarpang, Trongsa and Wangdue Phodrang. The Department of Energy (DOE) of the Ministry of Economic Affairs (MOEA) will be the Executing Agency (EA) and Renewable Energy Division under the DOE will be the Implementing Agency (IA). The DOE will outsource SHS O&M to BPC to be performed by BPC's contracted village technicians.

2.1 Initial Environmental Examination

60. The Initial Environmental Examination (IEE) was conducted to identify and assess the potential environmental impacts from implementing the SHS project to electrify the rural households and institutions. The SHS will not involve any land acquisition. The solar panels will be installed on the roof tops of the houses. The other components of the SHS such as controller, luminaries (LED bulbs), battery, wires and accessories will be inside the house. The RGOB's

current legislation does not require an environmental impact assessment for the SHS project. The proposed SHS project has been determined as Category B based on the Rapid Environmental Assessment described in the ADB's *Environmental Assessment Guidelines (2003)* and ADB's *Safeguard Policy Statement 2009*. This IEE report was prepared in accordance with ADB's *Safeguard Policy Statement 2009* with due consideration to environmental legislation of the Royal Government of Bhutan.

61. The IEE was prepared to meet the following objectives:

- To provide information about the general environmental settings in the targeted dzongkhags of SHS
- To provide information on potential impacts of the proposed SHS project and their characteristics (magnitude, distribution, and duration)
- To provide information on potential mitigation measures to minimize the impacts
- To provide information on the EMP to mitigate identified negative impacts
- To meet the ADB requirements for SHS project financing.

62. Field visits were made to collect the requisite information and for the preparation of the IEE from various government departments and other secondary sources (including public consultations).

2.2 Structure of IEE Report

63. The IEE report is divided in to ten chapters. The coverage of each chapter is summarized below:

- Chapter 1 describes the general background of the project and requirements of the IEE.
- Chapter 2 describes the policy, legal and administrative frameworks relevant to the project.
- Chapter 3 provides brief technical details of SHS, per unit cost and implementing and executing agencies
- Chapter 4 covers the environmental baseline description of the project areas.
- Chapter 5 summarizes the project's potential environmental impacts and mitigation measures
- Chapter 6 presents the analysis of alternatives
- Chapter 7 covers public consultations and information disclosure
- Chapter 8 describes grievance redress mechanisms for the project
- Chapter 9 describes institutional arrangements of the project's implementation and environmental management plans
- Chapter 10 summarizes the findings, recommendations and conclusions of the IEE.

2.3 Acknowledgements

64. The PPTA consultants gratefully acknowledge the cooperation received from the DOE, BPC, NEC, MOEA, Ministry of Agriculture and Forests, JICA and all dzongdag administrative offices of the project areas. The consultants would also like to extend their thanks for the cooperation and guidance received from Mr. K. Ogino, Senior Energy Specialist, Mr. H. Kobayashi, Senior Energy Specialist, Mr. S. Sasaki, Environment Specialist, Mr. S. Parwez, Programs/Project Implementation Officer, and Ms. P. Van Houten-Castillo of the ADB.

3. POLICY, LEGAL, AND ADMINISTRATIVE FRAMEWORK

65. The RGOB has enacted a number of acts and rules to safeguard the country's environment

3.1 Electrification Act 2001

66. Rural electrification is strongly promoted in the Electricity Act, 2001. Part 7, Section 61.1 states that "The Minister shall undertake to promote, support and provide rural electrification programmes through public and private sector participation in order to:

1. achieve equitable regional distribution and access to electricity;
2. maximize the economic, social and environmental benefits of rural electrification subsidies;
3. promote extension of the grid and development of off-grid electrification;
4. promote renewable energy."

67. The SHS project will help meet the aim of the Act to achieve equitable regional distribution and access to electricity and promotion of renewal energy.

3.2 Forest and Nature Conservation Act (FNCA) 1995

68. The Forest Act (1969) was the first environmental legislation in Bhutan and brought all forest resources under government custody to regulate utilization. This was repealed with the enactment of the FNCA in 1995, which allows community stewardship of forests, and aims to provide protection and sustainable use of forests, wildlife, and related natural resources. Schedule I lists those wild animals and plants that are given full protection under the Act. The disruption of trees is not expected at locations of SHS as these will be installed in the house of rural public. The FNCA establishes that all forests in Bhutan are Government Reserved Forests (GRF), and prohibits any development activity in these areas except with a permit. This Act will

not be applicable to the SHS project.

3.3 Forest and Nature Conservation Rules (FNCR) 2000:

69. Under powers established by the FNCA, the Ministry of Agriculture promulgated the FNCR in 2000, which was revised in 2006. Amongst other things the FNCR allows for:

- Allotment of land and land rights in GRF;
- Prohibitions, restrictions and concessions in GRF;
- Transport and trade of forest produce;
- Declaration and administration of protected areas;
- Protection of wildlife and use of certain wild species;
- Prevention of forest fires, land clearance, and activities potentially impacting soil, water and wildlife resources; and
- Enforcing penalties for offences related to these and other aspects of the FNCR.

70. None of these activities likely to be taken up in the SHS project, therefore, this act will not be applicable.

3.4 Protected Areas

71. Since 2008, five National Parks, four Wildlife Sanctuaries and one Strict Nature Reserve have been established in Bhutan. The RGOB's policies require that all proposed development projects within the boundaries of the protected area be subject to an EIA under the jurisdiction of the NEC. This initially included buffer zones outside the protected areas, but was extended to include Biological Corridors in 2006 by an addendum to the FNCR.

72. Biological Corridors (BC) are defined as "areas set aside to connect one or more protected areas, which shall be conserved and managed for the safe movement of wildlife." Although BCs do not have the same status as protected areas, activities such as new settlements, quarrying, mining, and leasing of land for grazing are prohibited. All other development activities, including construction of roads, electricity transmission and distribution lines, or any other structures, require a permit from the DOF and an EC application to the NEC, supported by an EIA.

73. The installation of SHS will be within the houses of rural population and no activity will be taken up in the protected areas and BCs. Thus, no impacts on these protected areas and BCs are expected.

3.5 Land Act 1979 (Revised 2007)

74. The Land Act 1979, which provides the basis for land tenure in Bhutan, was revised in 2007 to streamline its provisions. One major change was the establishment of an autonomous National Land Commission Secretariat that has been given full responsibility for all matters pertaining to land registration. Also the 20 land categories have been reduced to 7 in the revised Act including 1) *chhuzhing* (wetland), 2) *kamzhing* (dry land) including orchards, 3) *khimsa* (residential land), 4) industrial land, 5) commercial land, 6) recreational, and 7) institutional land.

75. Powers over land management have now been decentralized to local authorities like the Gewog Tshogdue, dzongkhag Tshogdue, and Thromdes. They are empowered to resolve land disputes and endorse land transactions and the conversion of land categories.

76. Under this Act, there are provisions for the acquisition of 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 depending on the land classification as per the prevailing land compensation rate determined by the Act. If a house is acquired, compensation is paid on the basis of an evaluation carried out by a qualified engineer appointed by the competent authority. No land acquisition is planned for the implementation of the SHS project; therefore, this act will not be applicable.

3.6 RGOB Decentralization Policy 2002

77. The Dzongkhag and Gewog Yargay Tshogdue Acts were implemented in 2002 to support the government's decentralization policy and empower locally elected community bodies (DYTs and GYTs) with the authority and responsibility to plan and implement development programs and activities, including those related to environmental management. Through this legislation the DYT is able to:

- Make recommendations on activities with major environmental impacts
- Designate and protect sites and monuments of cultural or historical interest
- Designate and protect areas of special scenic beauty or biodiversity, such as dzongkhag parks and sanctuaries
- Establish and enforce regulations to control noise pollution
- Prohibit the construction of structures within 50 ft of highways.

The GYT is able to establish and enforce regulations to:

- Control and prevent the pollution of air, soil and water
- Ensure safe disposal of waste and adequate standards of sanitation
- Conserve and protect water resources, including rivers, streams, springs and lakes.

The GYT also has custody of communal lands and community forests and can prevent encroachment onto lands and forests.

78. This policy will not be triggered due to the implementation of this SHS project as there will be no acquisition of land.

3.7 RGOB Environmental Clearance Procedure*s*

Environmental Classification

79. The NEC decides the environmental classification of projects on receiving the Environmental Clearance (EC) application submitted by the project proponent. There are three possible outcomes:

- The NEC may grant Environmental Clearance on the basis of the EC application if the application contains sufficient information and based on information submitted it is concluded that the proposed development will not have significant negative environmental impacts

- The NEC may deny Environmental Clearance on the basis of the EC application if the application contains insufficient information and it is clear that the proposed development will have significant negative environmental impacts that cannot be suitably mitigated

- If the EC application contains insufficient information on the likely nature and extent of the environmental impacts of the project or the manner in which they will be mitigated, the NEC will determine that an EIA is required.

3.8 Preparation of an EC Application

80. The requirements of the EC application are set forth in the sectoral guidelines that were revised with ADB assistance in 2006. The installation of SHS is not included in the government's list of activities requiring environmental clearance.

81. The information required for environmental clearance is very specific, and in all cases includes information on the applicant, the project, funding agency, the affected environment, potential impacts, mitigation, monitoring and public consultation.

82. There are three key elements of the EC application. These include the provision of signed no objection certificates (NOC) from all affected stakeholders/households, forestry

clearance from the Department of Forests, and dzongkhag administrative approval.

3.9 Conclusion

83. Based on the above reviews, none of the existing policies/acts is directly applicable to the SHS project. The installation of SHS is not included in the NEC's list of activities requiring environmental clearance. However, a series of discussions have been held with the NEC and based on their outcome the DOE prepared and submitted concept paper for obtaining a formal waiver of environmental clearance. Subsequently, the NEC had issued an environmental clearance exemption for this SHS project.

4. PROJECT DESCRIPTION

84. Bhutan is a mountainous country and rural electrification through the grid is not possible at many remote and isolated rural locations. The RGOB has set a target of Electricity for All by 2013. To achieve this target, solar home systems (SHS) will be installed at remote households.

85. **Objectives.** The objectives of project are to provide electrification in rural households where grid extension is not possible. The recipients are households in remote rural areas where more than 90% of the poor live.

86. **Project Targets.** The SHS project will be spread over 10 dzongkhags of the country, as shown in Table H-6.

Table H-6: Households Targeted for SHS by dzongkhag

S. No.	Name of dzongkhag	Targeted Number of Households
1	Chukha	563
2	Dagana	231
3	Gasa	188
4	Haa	170
5	Paro	44
6	Punakha	16
7	Samtse	177
8	Sarpang	177
9	Trongsa	70
10	Wangduephodrang	260
	Total	1,896

87. **Solar Home Systems.** The specifications for the proposed solar home systems take into

account the costs to transport the SHS to remote mountainous areas and improved system reliability, which will reduce maintenance requirements. Table H-7 shows the system components and specifications.

Table H-7: System Components and Specifications		
S. No.	**Component**	**Specifications**
1	Solar Panel	50 WP
2	Charge Controller	7 Amps
3	Luminaries	3 x 3 Watt WLED
4	Battery	50 AH@ c20, <32 kg
5	Night Lights	2 x 0.5 Watt LED
6	Mobile phone charge	Socket & cable
7	Wires	As available
8	Accessories	As available

88. The project design reflects the weather conditions, solar insolation resources, cable losses, pane degradation factors, battery and charge controller efficiencies and aging of components over time. In this sense, the design is regarded as conservative, but one that will perform well.

89. Bhutan has an average of 4.25 kW/m^2 per day of solar resources. Taking into account an overall efficiency loss of 56% on the PV panel and an additional loss of 30% due to battery inefficiency, cabling and environmental factors, the design components shown in Table H-7 were selected.

90. **Project Location.** The SHS is to be installed in Chukha, Dagana, Gasa, Haa, Paro, Punakha, Samtse, Sarpang, Trongsa and Wangduephodarang. The project implementation period will be 2011 to 2013.

91. **Costs.** The estimated costs of the project are shown in Table H-8.

Table H-8: Estimated Costs to Install 1,896 SHS Sets						
Item	**Nu 1000**			**US$ 1000**		
A. Base Cost	Foreign	Local	Total	Foreign	Local	Total
Materials	48,339		48,339	1,074	0	1,074
Installation		2,844	2,844	0	63	63
Implementation	0	928	928	0	21	21
Subtotal	48,339	3,772	52,110	1,074	84	1,158
B. PIU Costs	540	540	1,080	12	12	24
C. Contingency	9,580	845	10,425	213	19	232
Total Project Investment (A + B + C)	58,459	5,157	63,615	1,299	115	1,414

92. The Department of Energy (Ministry of Economic Affairs) will be the Executing Agency (EA), and Department of Energy's (DOE) Renewable Energy Division (RED) will be the Implementing Agency (IA) for the installation of SHS sets. The RED has managed the implementation of the Bhutan Solar Electrification Program since 2006 and managed the solar home electrification project well. The DOE will outsource SHS O&M services to the BPC.

5. DESCRIPTION OF THE ENVIRONMENT

5.1 Physical Resources

93. **Location.** The dzongkhags selected for the SHS project lie in the central, western and northern parts of Bhutan bordering China, India and Tibet (autonomous region of China). The total geographic area of the ten dzongkhags is approximately 21,000 square km^2. The total area of the country is 38,394 square km^2. Gasa dzongkhag has the largest area at 4,409.30 square km^2, whereas Punakha dzongkhag is the smallest at 974 square km^2.

94. There are about 50,000 households in the ten dzongkhags. Of these, 40-50% have been electrified. The minimum distance of the targeted dzongkhags from the capital city of Thimphu is around 52 km (Paro) and the maximum distance is about 270 km (Samtse). The prominent towns in ten dzongkhags are Gelephu (in Sarpang dzongkhag), Punakha, Chukha, Haa Dagana, Sarpang, Gasa, Wangdue and Samtse. All these towns are headquarters of the dzongkhags except Gelephu. Due to its proximity to the Indian markets, Gelephu is the main center of commercial activities in the Sarpang dzongkhag.

95. The target dzongkhags' elevations range from 200 m to 5,600 m above sea level. Parts of Haa have the highest elevation, at 5,600 m. In these higher zones SHS installation is not likely as there are no habitations. At the lower altitudes, the terrain is mostly flat or gentle and agriculture is the main land use. The topography of the dzongkhags extends to broad fertile valleys where agriculture and settlement are usually concentrated, especially near river banks at altitudes ranging from200 m to 5,600 m above sea level.

96. The average percentage under forest cover in the targeted dzongkhags is 64%. About 5.5% is under agricultural production. Chukha has highest percentage of forest cover. Within the forested area broadleaf forest dominates with percentages ranging from 30-95%. The next dominant category of forests is conifer.

97. All the dzongkhags fall within the Lesser Himalayan formation, which includes a wide range of sedimentary and low-grade metamorphic rocks such as argillites and metargillites, sandstones and quartzites, limestone, dolomite and gypsum. Gneisses underlie more than 70% of the country. Shumar and Manas formations occur in some of dzongkhags such as Sarpang. The Shumar formation comprises alternating sequences of quartzite and phyllite/mica schist

with bands of carbonate lenses of gypsum and sheet-like mylonitised granite gneiss as well as basic silts. The Manas formation comprises dolomite, limestone, phyllite and quartzite. Eastwards towards Gelephu and beyond, the quaternary conglomerate comprises mainly sand, silt and clay. The valley along the Sarpang-Tsirang road is dominated by argillaceous and arenaceous sediments.

98. The soil types found in all 10 dzongkhags range from sandy, clay, loam to sandy loam and clayey loam. Generally the soil in the alluvial lowland river valleys is quite fertile and crops grow well as soil moisture is also adequate in the foothills. At lower altitudes, many of the slopes are covered with colluviums, a mixture of soil and stones deposited by slow creep and many small landslips and slumps. At slopes soils are shallow.

99. **Climate.** The climate in the project areas varies with altitude. Higher altitudes have cool temperatures with warm humid summers and chilly winters with snowfall in some parts, the lower elevations experience sub-tropical to temperate climate. The Wangduephodrang dzongkhag is windy.

100. The relative humidity in the project areas ranges from 63% to 90%, with an average of about 70%. The least humid period is during the monsoon season (March-May). The average mean temperature for the warmest months of June and July is about 20-30° C, while the mean temperature for the coldest months of January and February is about 10-12° C. In January and December temperatures at locations of higher altitudes such as Gasa drop to minus 2° C.

101. The average annual rainfall ranges from 600 mm to 5,000 mm, but sometimes the precipitation is much heavier. The precipitation is heaviest from June to September.

102. **Air Quality.** Air pollution in Bhutan is a recent phenomenon that can be attributed to rapid urbanization. Diesel vehicles' exhaust gases are the major sources of urban air pollution. No information is available on the ambient air quality of the ten dzongkhags because so far ambient air quality (PM, NOx and SO_2) monitoring has only been conducted in Thimphu and Phuentsholing. The average inhalable particulate matter (PM10) concentration of 24.5 $\mu g/m^3$ in Thimphu is lower than the international ambient air quality standard of 40 $\mu g/m^3$. Since all ten dzongkhags have a much lower population and less construction, industrial and vehicular activity, their air quality is expected to be much better than that of Thimphu. Hence, air quality is not a concern in the project areas. The project will not generate air pollutants, so ambient air quality is not a concern.

103. **Surface Water.** Each dzongkhag has perennial rivers and local streams that drain the area. The prominent streams are Maokhola Chu, Shetikahray Chu and Dawalakhola Chu in Sarpang, Wong Chu in Chukha, Paro Chu in Paro, Phegu Chu, Tong Chu, Pho Chu, Mochu and Punatsang Chu in Gasa, Tsang Chu, Dang Chu, Kisona Chu and Hangra Chu in Wangduephodrang, Pho Chu, Mochu, and Sankosh Chu in Punakha. Haa and Dagana are drained by tributaries of the Wong Chu, while Trongsa is drained by the river system mentioned for Wangdue. Torsa River drains Samtse dzongkhag. In addition to these rivers there are smaller

streams that join these rivers in the respective dzongkhags. During the monsoon, heavy rains often cause flash floods in the valleys which are very vulnerable to erosion due to land cultivation. The construction of embankments in the erosion-prone areas is being undertaken. Surface water quality data for the project areas are not available, but because there are no pollution discharge sources to these rivers, they are considered to be pristine.

104. **Groundwater.** Groundwater resources are abundant with springs emerging from underground rocks, old landslides and fluvial deposits. Groundwater in landslide and alluvial deposits has been estimated at an exploitable rate of 3 liters/second/km^2. Currently water quality monitoring is only conducted in the four major river systems of Bhutan. Generally, Bhutan's groundwater quality is still good but with expanding settlement along rivers, there are localized pollution problems. The SHS project will not require any groundwater for construction or operation.

105. **Noise.** Data on measured noise levels are not available in the project area as currently the NEC is measuring noise levels only in Phuentsholing and Thimphu. Major contributors to ambient noise levels are commercial activities and vehicular traffic. In the project areas, noise levels are expected to be within the ambient standard noise standards set by the NEC for Rural and Residential areas (55 dB(A) during the day and 45 dB(A) at night. The SHS project will not have any noise generating activities during construction and operation.

106. **Aquatic Environment.** A total of 41 indigenous fish species are known in the rivers and lakes of Bhutan. This includes eight exotic species like the coldwater trout, and other species introduced for warm water aquaculture, namely grass carp (ctenopharyngodon idella), common carp (cyprinus carpio), silver carp (hypothalmicthys molitrix), catla (catla catla), rohu (labeo rohita), mrigal (cirrhius mrigala). Some of the fish species found in the river in Sarpang are schizothorax progastus (asla), schizothorax moleworthii, acrossocheilus hexagonolepis, crossocheilus latius, tor putitora (mahseer), tor tor (mahseer), barilius barna, barilius bendelisis, puntius macropogon, puntius sophore, puntius ticto, puntius titus, barbus spp., labeo dero, garra annandalei, garra gotyla, danio aequipinnatus, danio dangila, brachydanio rerio, botia dario, rasbora daniconius, noemacheilous botia, batasio, mystus bleekeri, mystus vittatus, ompok pabda, channa striatus and Mastacembelus armatus. The same species will be prevalent in the river systems described above.

5.2 Ecological Resources

Protected Areas. Parts of the ten dzongkhags selected for SHS installations fall in six protected areas. These include Jigme Singye Wangchuk National Park (JSWNP), Royal Manas National Park (RMNP), Philbsoo Wildlife Sanctuary (PWLS), Torsa Strict Nature Reserve (TNSR), Black Mountain National Park (BMNP), and Jigme Dorji National Park (JDNP). As SHS sets are to be installed in the houses of the villagers, no impacts on the protected areas are anticipated.

107. **Rare or Endangered Species.** Some notable species found in the protected areas mentioned above are the tiger (panthera tigris), elephant (elephas maximus), himalayan black bear (selenarctors thibetanus), sloth bear (Melursus ursinus), leopard (panthera pardus), and gaur (bos gaurus), and endemic species such as the golden langur (presbytis geei) and spotted deer (axis axis) (Table H-9).

108. Species such as the one-horned rhinoceros (rhinoceros unicornis), hispid hare (caprolagus hispidus) and pygmy hog (sus salvinus) are said to exist in Royal Manas but have rarely been sighted. Other commonly species include barking deer (muntiacornis sumatraensis) Indian porcupine (hysterix indica) and goral (naemorhedus goral). In addition to this there are a number of snake species.

Table H-9: Endangered or Vulnerable Species Expected in Protected Areas

Common Name	Scientific Name	IUCN Red List Category	Bhutanese protection Category
Golden Langur	Presbytis geei	EN	Schedule I
Sloth Bear	Melursus ursinus	VU	Schedule I
Himalayan black Bear	Selenarctors thibetanus	VU	Schedule I
Clouded Leopard	Neofelis pardus	V	Schedule I
Common Leopard	Panthera pardus	LC	Schedule I
Tiger	Panthera tigris	EN	Schedule I
Asian Elephant	Elephas maximus	E	Schedule I
Leopard Cat	Prionailurus bengalensis	LC	Schedule I
Capped Langur	Trachypithecus pileatus	EN	Schedule I
Marbled Cat	Felis marmorata	VU	Schedule I
Wild Dog	Cuon alpines	EN	Schedule I
Gaur	Bos gaurus	V	Schedule I
Spotted Deer	Axis axis	EN	Schedule I

EN = Endangered, VU = Vulnerable, LR = Lower Risk, NT = Near threatened, LC = Least Concern IUCN = International Union for Conservation of Nature.

109. **Biodiversity.** The dominant forest type in all 10 dzongkhags is broadleaf, accounting for 30% to 95% of the forest areas. The second dominant category of forest is mixed conifer forest. The forests in the protected areas mainly comprise subtropical forests, warm broadleaved forest and cool broadleaved forests. Trees commonly found in the subtropical zone, which extends 200 m to 1,000 m, include bombax ceiba, ailanthus grandis, dillenia pentagyna, duabange grandiflora, schime wallichii, tetrameles nudiflora, mangifere sylvatica, terminalia myriocarpa, ostodes paniculata and species of musa, polyalthia, castanopsis, cinnamomum, fisus and grewia.

110. The warm broadleaved zone extends between elevations of 1,000 m to 2,000 m and comprises species such as alnus nepalensis, macaranga spp. altinga excelsa, castanopsis indica, michelia excels, bombax spp., ficus spp., terminalia spp., acacaia, dalbergia, mussaendra roxburghii rhaphidophora species, maesa spp., albizzia spp., dichroa febrifuga and engellhardia spicata.

111. The cool broadleaved forest is found at elevations ranging from 2,000 m to 5000 m and comprise mainly betula alnodes, elastotema spp., symplocus spp., lindera pulcherrima, persea spp., exbuckllandia populnea, cantanopsis hystrix, lithocarpus elegans, and eurya spp.

112. **Wildlife.** A wide variety of fauna inhabits the forest areas including the protected species listed in Table H-9. A list of avifauna found or expected to be found in the dzongkhags of the SHS project is given in Table H-10. Table H-11 lists the protected species in the Forest and Nature Conservation Act 1995. No endangered species of flora or fauna is anticipated at villages where SHS are to be installed. These areas are already affected by human activities due to the transportation from/ to their villages. Therefore, no significant impact on flora, fauna or avifauna is expected due to the project activities.

Table H-10: Avifauna of the Project Areas		
S. No.	**Common name**	**Scientific Name**
1	Ashy Drongo	Dicrurus leucophaeus
2	Ashy Woodswallow	Artamus fuscus
3	Asian barred Owlet	Glaucidium cuculodies
4	Asian Palm Swift	Cypsiurus balasiensis
5	Asian Paradise-flycatcher	Tersiphone paradisi
6	Barred Cuckoo Dove	Macropygia unchall
7	Bar-winged Flycatcher-Shrike	Hemipus picatus
8	Block Stork	Ciconia nigra
9	Black-backed forktail	Enicurus picatus
10	Black-crested Bulbul	Pycnonotus melanicterus
11	Black-throated Sunbird	Aethopyga saturate
12	Blue-throated Barbet	Megalaima asisatica
13	Blue-winged Minla	Minla cyanouroptera
14	Blyth's Leaf Warbler	Phylloscopus reguloides
15	Bronzed Drongo	Dicrurus aeneus
16	Chestnut-bellied Nuthatch	Sitta castanea
17	Chestnut-headed Bee-eater	Merops leschhenaulti
18	Chestnut-tailed starling	Sturnus malabaricus
19	Collared Owlet	Glaucisium brodiei
20	Common Myna	Acridotheres tristis
21	Common Stonechat	Saxicola torquata
22	Common Tailobird	Orthotomus sutorius

Table H-10: Avifauna of the Project Areas		
S. No.	**Common name**	**Scientific Name**
23	Crow-billed drongo	Dicrurus annectans
24	Dollarbird	Eurystomus orientails
25	Drongo Cuckoo	Surniculus lugubris
26	Emerald Dove	Chalcophas indica
27	Eurasian Tree Sparrow	Passer montanus
28	Golden-fronted Leafbird	Chalophaps indica
29	Great Barbet	Megalamia virens
30	**Great Hornbill**	**Buceros bicornis***
31	Greater Neclaced Laughingthrush	Chrysocolaptes lucidus
32	Greater Racket-tailed Drongo	Garrulax pectoralis
33	Greater Yellownape	Dicrurus pectoralis
34	Grey Wagtail	Picus flavinucha
35	Grey Wagtail	Motacilla cinerea
36	Grey-Backed Shrike	Lanius tephronotus
37	Hill Myna	Gracula religiosa
38	House Crow	Corvus splendens
39	Indian Pond Heron	Ardeola grayii
40	Large Woodshrike	Tephrodornis gularis
41	Large-billed Crow	Corvus macrorhynchos
42	Lesser Racket-Tailed Drongo	Dicrurus remifer
43	Lesser Yellownape	Picus chlorophus
44	Long-tailed Broadbill	Pasarious dalhousiae
45	Long-tailed Shrike	Lanius schach
46	Mountain Imperial Pigeon	Ducula badia
47	Mountain Scops Owl	Otus spilocephalus
48	Orange-bellied Leafbird	Chloropsis hardwickii
49	Oriented Honey-buzzard	Pernis Ptilorhyncus
50	Oriental Magpie Robin	Cospsychus saularies
51	Oriented pied Hornbill	Anthraceros albirostris
52	Osprey	Pandion haliaetus
53	Pale-chinned Flycatcher	Cyornis poligenys
54	Pin-tailed Green Pingeon	Treron apicauda
55	Plain Flowerpecker	Dicaeum concolor
56	Red-headed Trogon	Harpactes erythrocephalus
57	Red-rumped Swallow	Hirundo daurica
58	Red-tailed Minla	Minla ignotincta
59	Red-vented Bulbul	Pycnonotus cafer
60	River Lapwing	Vanellus duvaucelii
61	Rifous Woodpecker	Celeus brachyurus
62	Rufous-bellied Niltava	Niltava sundara
63	Ruffous-necked Hornbill	Aceros nipalensis
64	Scaly Thrush	Zoothera dauma

Table H-10: Avifauna of the Project Areas		
S. No.	**Common name**	**Scientific Name**
65	Scarlet minivet	Pericrocotus flammeus
66	Slaty-blue Flycatcher	Ficedula tricolor
67	Small Niltava	Niltava macgrioriae
68	Snowy-browed Flycatcher	Ficedula hyperythra
69	Spangled Drongo	Dicrurus hattentottus
70	Spotted Dove	Streptoplia chinenesis
71	Streaked Spiderhunter	Arachnotherea magna
72	White Wagtail	Motacilla alba
73	White-rumped Shama	Copsychus malabaricus
74	White-throted Kingfisher	Halcyon smymensis
75	Wreathed Hornbill	Aceros undulates
76	Yellow-bellied Fantail	Rhipidura hypoxantha
*Near threatened species globally		

Table H-11: Species Listed in the Forest and Nature Conservation Act		
Common Name	**Scientific Name**	
Schedule 1A – Protected Wildlife		
Asian Elephant	Elephus maximus	
Clouded Leopard	Neofelis nebulosa	
Golden Langur	Presbytis geei	
Musk Deer	Moschus Chrysogaster	
Pangolin	Manis crassicaudata	
Pigmy Hog	Sus sylvanicus	
Snow Leopard	Panthera unica	
Takin	Budorcas taxicolor	
Tiger	Panthera tigris	
Wild Buffalo	Bubalus bubalis	
Golden Masheer	Tor tor	
Spotted Deer	Axis axis	
Gaur	Bos gaurus	
Leopard	Panthera pardus	
Leopard Cat	Felis bengalensis	
Himalayan Black Bear	Selenarctos thibetanus	
Red Panda	Ailurus fulgens	
Serow	Capricirnis sumatraensis	
Protected Birds		
Black-Necked Crane	Grus nigricollis	
Monal Pheasant	Lophophorus impejenus	
Peacock Pheasant	Polyplectron bicalcaratum	
Raven	Corvus corax	
Rufous-Necked Hornbill	Aceros nepalensis	
Schedule – IB : Protected Plant Species		
Local Name	**Common Name**	**Botanical Name**
Agar/ agaru	Eagle Wood	Aquilaria malaccensis
Yartsa-guenboop	Chinese Caterpillar	Cordyceps sinensis
Pang-gen metog	-	Gentiana creassuloides
-	Snow Down Lily	Llyodia yummanesis
Tsher-ngeon	Blue Poppy	Meconopisis grandis
Kirang-shing	Yew	Taxus baccata
Bhreeng-geeradza Ginseng	-	Panax pseudo-ginseng

5.3 Economic Development Resources

113. **Land Use, Industry and Agriculture.** The predominant land use in the project areas is forest. The average percentage of forest area in each dzongkhag is 60% except Chukha and Dagana, where forest percentages are 82% and 80%, respectively. The cultivable area is less

than 8% in all ten dzongkhags. The percentage of area under settlement is about 0.3%. The area under pastures is around 4%. The balance of land use is in water bodies and rocky areas. Due to the flat terrain, fertile sedimentary soil layers, and suitable climatic condition, most of the arable wetland is now under rice cultivation in the southern and central dzongkhags of Sarpang, Samtse, Chukha, Paro, Punakha and Wangduephodrang and Dagana. Due to its high production of rice, Sarpang is known as the "Rice Bowl of Bhutan."

114. The major crops produced in the project areas include maize, wheat, buckwheat, barley, mustard, finger millet and foxtail millet along with a wide variety of green vegetables. Potato producing areas are Haa and Paro. Oranges are grown in almost all of the country's southern dzongkhags; cardamom, areca nut, ginger, guava, lemon, banana and mango are also grown extensively in the plains areas close to the Indian border.

115. Almost every household in all 10 dzongkhags owns some livestock (mostly local breeds) to meet their need for milk, butter, cheese, meat and manure. Livestock also plays an important role in the rural areas by providing draught power in the absence of mechanized farming. For those villages near towns, any surplus farm products are taken to towns for sale.

116. Most of the existing industrial establishments in Bhutan are small-scale or cottage industries. In the project areas industries exist in Samtse and Sarpang and Chukha. Phuentsholing, the largest industrial area, is located in Chukha. There is good growth potential for industries in Gelephu, where a new airport is planned. Two major hydropower projects owned by Chukha Hydro Power Ltd. and Tala Hydro Power Ltd. are located in Chukha dzongkhag.

117. **Administrative Infrastructure and Community Facilities**. All dzongkhag headquarters in the project areas – Chukha, Sarpang, Dagana, Damphu, Gasa, Haa, Paro, Punakha,Trongsa, Phuentsholing and Wangdue – have administrative offices (e.g., forests, revenue, courthouses). These dzongkhags also have public service establishments such as banks, post offices and communication centers.

118. The numbers of educational facilities (schools) in Chukha, Dagana, Gasa, Haa, Paro, Punakha, Samtse, Sarpang, Trongsa and Wangdue Phodrang are 36, 4, 8, 23, 22, 16, 13, 18, 16 and 36, respectively. Health facilities are available in all 10 dzongkhags. These facilities include referral hospitals, basic health units, and outreach clinics (Chukha Dzongkhag has 3 hospitals, 9 basic health units and 28 outreach clinics; Wangdue dzongkhags has 10 basic health units and 33 outreach clinics. Trongsa dzongkhag has 5 basic health units and 21 outreach clinics. Gasa dzongkhag has 4 basic health units and 8 outreach clinics. Punakha has 2 basic health units, and 3 outreach clinics, and Paro has one referral hospital, 12 basic health units and 26 outreach clinics. Livestock extension centers, agriculture extension centers, and rural water supply schemes also exist in each dzongkhag.

119. **Transportation.** Transportation in all dzongkhags is through road and mule tracks. Remote locations at high elevations are connected through mule track. Bhutan's only

international airport is at Paro in Paro dzongkhag. There is no rail head in any of the dzongkhags. A new airport is proposed at Gelephu in Sarpang dzongkhag.

120. **Electricity and Communications.** The households close to dzongkhag head quarters have been electrified. Based on the information available on dzongkhag websites, the numbers of households electrified are 1,563 in Samtse, 2,197 in Sarpang, 10,323 in Chukha, and 1,490 in Wangdue Phodrang. In other dzongkhags, the exact number of households electrified is not known, but based on discussions with the RED, it is believed that about 70% are electrified.

121. All dzongkhag headquarters are connected by line telephones. All dzongkhag towns have mobile connectivity.

122. Telephone exchanges are available at every dzongkhag head quarters.

123. **Social and Cultural Resources.** The population of Bhutan includes many ethnic groups such as the Sharchops in the east, Ngalongs in the west, Khengpas in the central region, nomads in the north and Lhotshampas in the south. Because of the mix of ethnicities, a wide variety of dialects are spoken, of which Dzongkha, Khengkha, Sharchop and various dialects of Nepali are the most common. The majority of the population is Buddhist (around 70%) and the remainder is mainly Hindu, mostly in the southern areas.

124. The project areas have a sex ratio of 1:1. In the project areas about 70% of the population is rural residents while 30% is urban dwellers. The average number of family members per household is 4.7. The employment rate is about 34%. Around 73% of the households own land, 57% own their home, 8% own their own business, and 7% own a vehicle.

125. There are a few culturally important monasteries and other important culture structures in Wanagdue, Punakha and Paro. In Paro, the Takshtang monastery is very famous and a tourist destination. Kichu Lakhang is also very famous. There are a few culturally significant sites in Wangdue. The Dzong located at the junction of the Pune Tsang Chu and the Dangchu was founded by Zhabdrung Ngawng Namgyal in 1638. The Gangtey Goenpa is the Nyingmapa monastery in western Bhutan. It was founded by the grandson of Pema lingpa, Gyalse Pema Thinley in 1613 and later was expanded by Tenzin Legpau Dhendup. The Bey Langdra Nye is located in the center of a ridge at Bey Yul in Kazhi geog. It is famous as the site where Guru Rinpoche is said to have mediated for seven days and suppressed the spirits that came to attack him.

126. Punakha dzongkhag is significant historically as the place of enthronement for the first hereditary Monarch, King Ugyen Wangchuck on 17 December 1907. It served as the winter capital until 1955 and Punakha Dzong continues to be the winter residence of the Central Monk Body. The Pungthang Dechen Phodrang in Punakha Dzongkhang was constructed by Zhabdrung Ngawang Namgyel in 1637 and is renowned for its historical importance.

127. Dzongkhags typically have government-owned, public as well as private Lhakhangs.

These include the famous Talo Lhakhang, the Bjaching Karm nunnery and the newly built Lhakhang at Kabjisa.

128. In Bhutan traditions are followed religiously. Male and female traditional dresses are the Kho and Kira, respectively. In almost all the ten dzongkhags of the project areas traditional dress is worn. In Gasa dzongkhag Layaps (from Laya) and Lunaps (from Lunana) are unique because they have their own dress, language, culture and tradition. The communities in Laya and Lunana Gewogs in Gasa dzongkhag are semi-nomadic yak herders who spend time between the villages and the high-altitude yak herding camps. Cheese and butter are prepared and stored to be sold or bartered either in Punakha or across the border. They have a distinct traditional dress made of yak wool that is suitable for the extremely cold and harsh winters. Due to the snow, the high mountain passes are inaccessible in winter causing much hardship for the communities and their yaks. During the winter months, many of the households migrate to lower regions where they purchase their food stock for the rest of the year.

129. In other dzongkhags there are no culturally significant structures. Most of the larger villages have a temple, and there are smaller Buddhist shrines both inside and outside inhabited areas, and various other places or objects that are of significance to the community, including particular trees, river and other locations.

6. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATING MEASURES

130. Based on the baseline environmental features of the SHS project areas described in Section 5, this section discusses the environmental impacts and mitigation measures anticipated during the installation and operations phases. Each sub-project was categorized using a rapid environmental assessment (REA) checklist. REA uses sector-specific checklists that are developed based on the ADB's knowledge and experience. These checklists consist of questions relating to 1) the sensitivity and vulnerability of environmental resources in the project areas and 2) the potential for the project to cause significant adverse environmental impacts. Based on the REA checklist, this project is classified as category B.

6.1 Environmentally Insignificant Issues

131. Although the dzongkhags where SHS are to be installed have forest areas, protected areas and local wildlife, the SHS project is not going to impinge on them as SHS installations will be located in houses. These habitations will be away from the environmentally sensitive areas such as national parks, wildlife sanctuaries, Nature reserves, and biological corridors.

132. Based on the checklist, the following impacts are regarded as insignificant:

- **Physical Resources:** Geology, climate, ambient air quality, surface water sources and

quality, groundwater sources and quality, ambient noise levels, rural services/utilities(water supply, electricity, and telephone lines, etc.)

- **Ecological Resources:** Protected areas, rare and endangered species, wildlife, and biodiversity

- **Economic Development Resources:** Land use, industries, agriculture, tourism, transportation, electricity and communication, and administrative infrastructure

- **Social and Cultural Resources:** Demography, history and culture, involuntary resettlement.

6.2 Environmentally Significant Issues /Valued Environmental Components

133. Based on the REA checklist, field visit and discussions with various government officials, a few issues have been identified as valued environmental components (VEC). The potential impacts and proposed mitigating measures are summarized in the following sections.

6.3 Topography and Soil Environmental Impacts and Mitigations

Impacts

134. **Installation Phase.** The projects will not have any significant impact on topography. The PV panel, however, will be visible on the rooftop of house. This small change in topography will permanent. There will be no impact on the areas' soil quality during this phase.

135. **Operations Phase.** In addition to the PV panels changing the areas' topography, batteries will have to be replaced after three to five years. These batteries contain lead and sulfuric acid. If the batteries are not properly disposed, soil contamination will occur.

Mitigation Measures

136. **Installation Phase.** Since no impact on soil has been identified during this phase, no mitigation measures are necessary. The change in topography from the PV panels will not be aesthetically displeasing as people have habituated to seeing utility poles, communication towers, etc. Hence, no mitigation measures are warranted.

137. **Operations Phase.** The village technicians of BPC will provide operation and maintenance services to SHS. If a battery is discharged and to be replaced, the village technicians will arrange for the used battery to be taken to BPC's nearest Customer Service Center. The DOE SHS O&M manger will arrange for a truck to pick up the used batteries stored at BPC's CSCs periodically. These batteries will be shipped to Phuentsholing. Then the

DOE/RED will arrange to turn over these batteries to authorized battery recyclers in India. This should be a leak-proof battery collection system. Hence, no impacts are anticipated on soils and environment of the project area.

138. In case acid leaks from the used batteries during transport, the spilled acid will be diluted with water. The village technicians and transporters will be trained for such accidental situations.

139. Since the minor visible changes in topography are permanent but minor, no mitigations are warranted for this.

6.4 Human Health

Impacts

140. **Installation Phase.** No adverse impacts on health are expected as emissions, effluents and solid wastes will not be generated.

141. **Operations Phase.** During the operations phase, no negative impacts are anticipated. There will be positive impacts on the health of the population, which currently uses either kerosene or candles for lighting, which generates smoke and has adverse impacts on health. Due to SHS installation, there will be no generation of smoke.

Mitigation Measures

142. **Construction Phase.** Since no adverse impacts have been identified, no mitigation measures are warranted.

143. **Operations Phase.** Again, no adverse impacts have been identified, so no mitigation measures are necessary.

6.5 Biodiversity

Impacts

144. **Installation Phase.** No impact on biodiversity is expected during the installation phase as there will be no cutting of trees in open areas, protected areas or forests***.***

145. **Operations Phase.** No impact on biodiversity is anticipated during the operation phase as there is no generation of emissions, effluents or solid wastes. There will be no noise impact either as operating SHS does not generate noise.

Mitigation Measures

146. Since no impacts have been identified during the installation and operation phases, no mitigation measures are warranted.

6.6 Social and Environmental Benefits

147. The proposed SHS project will use solar energy – a clean, sustainable and renewable energy – for lighting in rural homes. The project will have a host of environmental and social benefits, including:

- Use of clean and sustainable solar energy
- Reduction in kerosene and candle consumption for lighting
- Reduction in greenhouse gas emissions as a consequence of reduction in kerosene consumption
- No social issues and no cutting of trees
- Cost effective
- Direct and indirect employment opportunities
- No loss of energy in transmission in power network.

6.7 Conclusion

148. Based on the above assessments, it is concluded that negative impacts due to the implementation of the SHS project are limited. Impacts are anticipated during operation from the replacement of used batteries after three to five years. These will be mitigated through a leak-proof collection system.

7. ANALYSIS OF ALTERNATIVES

149. Three alternatives were considered for the SHS project. These were 1) No Project Scenario (No SHS installation), 2) Project Scenario, and c) another form of energy such as micro hydropower for lighting. These alternatives are assessed below.

7.1 No Project Scenario

150. The SHS project has insignificant environmental impacts. The RGOB has set a target to provide electricity to all by 2013. To achieve this target, SHS will be installed for households in remote and isolated rural areas where extension of grid is not feasible. Under the No Project scenario, it will be impossible to meet the RGOB’s electrification target. The unavailability of

electricity will be an impediment to the economic growth of the rural poor. The No Project scenario has no environmental advantages, either. Currently the kerosene and candles used by the rural population for lighting results in greenhouse gas emissions and indoor smoke generation, which are harmful to the environment and health. Hence, the No Project scenario will be detrimental to the rural population's economic growth and the environment.

7.2 Project Scenario

151. The project scenario will provide a clean form of energy in the rural areas and will result in the reduction of greenhouse emissions and smokes. There will be positive impact on the health of rural households due to the use of solar energy for lighting. There will be economic development due to the availability of solar lighting. Rural children will get good-quality lighting for their studies. The working hours for homemakers will increase, as they will have more time to work in their agriculture fields. This will lead the country to the path of growth and poverty reduction. The project will also help achieve the target of the RGOB for 100 % electrification in the country.

7.3 Other Form of Energy Scenario (Micro Hydropower Project)

152. It will take time to finalize the locations and install micro hydro stations. The extension of local distribution lines from micro hydro stations to households may be problem for techno-economic reasons and because of difficult terrain conditions. In addition, many past micro hydropower projects failed due to the lack of spare parts and proper operation and maintenance skills of the villagers. This alternative is very difficult and costly to implement in Bhutan.

7.4 Comparison of Alternatives

153. Comparative assessments of the three alternatives are summarized in the Table H-12.

Table H-12: Comparison of Alternatives

Parameters	No Project Scenario	Project Scenario	Other Form of Energy (Micro Hydro)
Economic cost	Use of kerosene/candles is financially very cheap.	SHS will cost about Nu 27,000 per set The RGOB is installing the SHS free of cost, but during the operation phase there will be a	High cost and may not be feasible to install due to terrain and techno-economic reasons Will take a long time to finalize proper locations and

Table H-12: Comparison of Alternatives			
Parameters	**No Project Scenario**	**Project Scenario**	**Other Form of Energy (Micro Hydro)**
		charge of 10% of the spare part costs from the owners of the SHS system	the target of electrification will not be achieved. Power generation will drop substantially in the winter dry seasons
Developmental impacts & people's perceptions	Village/Gewog considered underdeveloped	Community will be considered developed	Community will be considered developed
Social benefit	The lighting quality is poor from kerosene and candles lamps; this will cause problems when working and studying	Clean and renewable energy The lighting quality will be good for studying and other domestic activities It can be installed anywhere without any problems No significant recurring cost to households as O&M will be subsidized	Hydropower is also clean energy. But during the winter season, due to low flows in rivers, its functioning is questionable Electricity supply at many villages is not possible due to the difficulty in extending distribution lines due to terrain conditions
Environmental impacts	There will be continued impacts due to emissions of greenhouse gases due to the burning of fossil fuels. Hence, there will be negative impacts on environment	No adverse environmental impacts Greenhouse gas emissions will be reduced Effective and leak-proof collection of used batteries is planned	Extending distribution lines will involve cutting of trees in the grid's right of way. This will have negative impacts on forests. In some situations extending distribution lines from micro hydro may not be possible due to difficult terrain
Health	Negative impact on health due to smoke generation	Positive impact on health as solar is a clean form of energy	Positive impact on health

7.5 Conclusion

154. Based on the above assessments, the installation of SHS in the targeted 10 dzongkhags in central, southern and western Bhutan is the best alternative among those considered. The

SHS will improve the quality of life of households participating in the project.

8. INFORMATION DISCLOSURES AND CONSULTATIONS

155. The successful implementation of the project requires the coordinated efforts of all stakeholders. Hence, consultation at different levels was used as a tool to inform and educate stakeholders about the proposed action both before and after the project implementation decisions were made. Public consultation was useful for gathering environmental data, and understanding likely impacts and community needs and preferences.

156. Various alternatives could evolve and sustainable mitigation measures could be formulated through consultations. The consultants assisted in the identification of the problems associated with the project as well as the needs of the population likely to be impacted (benefits in this case). This participatory process helped in positively influencing people's perception and enabled the participation of the local people in the decision making process. The involvement of the various stakeholders ensured that the targeted population and other stakeholders are informed, consulted and allowed to participate in the project's various stages.

8.1 Objectives

157. The main objective of the consultation process was to inform the stakeholders, seek their inputs and maximize the benefits of the project. Other objectives of the consultation process were to:

- promote public awareness about the proposed SHS project in the project area of 10 targeted dzongkhags
- educate the communities/individuals about the benefits of the SHS system
- solicit the views of communities/individuals residing in the targeted dzongkhags on solar energy
- gather inputs from the targeted population/individuals for improvements in project configuration and implementation procedures
- stimulate community self-evaluation and analysis
- ensure a lessening of public resistance to change by providing them a platform in the decision making process.

8.2 Methodology Adopted for Public Consultations

Stages and Levels of Consultation

158. Consultations were held in the period December 2009 to February 2010. The consultations were conducted at three levels and various tools were used.

- **local level** consultations at the Chiwog (village) level/Geog (Block) level in targeted dzongkhags for the proposed SHS installations
- **dzongkhag level** consultations involving Dzongadag, local BPC officers, local forest department, and dzongkhag environmental officers
- **Institutional level** consultations with the National Environment Commission (NEC), Bhutan Power Corporation Ltd., Department of Energy, JICA, ADB, etc.

Tools for Consultation

159. **Formal and Informal Discussions.** During visits to Gewogs in all dzongkhags, formal discussions have been held with Dzongdags and informal discussion with locals and Gups (village heads). A checklist of questions was kept ready and responses were elicited from people. The focus group discussions have been held in targeted dzongkhags.

160. **Consultative (Inception) Workshop.** At the institutional level, consultations were held with representatives of institutions having stakes in the project's implementation. The participants included the NEC, BPC, and Department of Energy (DOE).

161. An inception workshop was organized on December 3, 2009 by the PPTA consultants and all institutional stakeholders were invited with a view to invite comments and suggestions on the SHS project.

162. The consultations with institutional officials focused on the following issues.

- Project description: Need for renewable energy from biogas, solar and wind
- Advantages and low level of pollution(emissions/effluents/solid wastes)
- The extent and nature of social and environmental impacts
- People's participation in planning, implementation, monitoring and evaluation stage.

8.3 Summary of Local Consultations

163. A number of consultations at the village and block levels were held in three selected dzongkhags. The key views of participants are summarized below. The list of participants is available on request.

Public Consultation at Tongtsho Village, Tseza Geog, Dagana Dzongkhag, January 19, 2010

164. Seven households participated in the public consultation. The households of Tongtsho were not happy about receiving solar home systems as they preferred on-grid electricity connection. The participants also expressed concern about the feasibility of solar home systems as the weather at Tongtsho is cloudy most of the time and they were not sure whether a solar home system would work in their village.

Public Consultation at Doban Geog, Sarpang Dzongkhag, January 12, 2010

165. Fifteen people participated in this public consultation. Their preference was for on-grid electricity connection. However, after the consultant explained the technical and economic constraints on the part of the government, participants showed satisfaction with solar home systems, but insisted that they should be installed at no cost to them. One more concern expressed by the participants was that the batteries would be expensive and difficult to transport when replacements were needed.

Public Consultation at Thasa Village, Lajab Geog, Dagana Dzongkhag, January 23, 2010

166. Five households participated in the public consultation and expressed that they would prefer being connected with electricity distribution lines rather than solar home systems. Their concern was with the systems' operation and maintenance, as none of the people in the village have experience in solar home systems, and some had never seen a properly functioning SHS.

Public Consultation at Upper Majgaon Village, Patalay Geog, Tsirang Dzongkhag, January 28, 2010

167. The four participants in the meeting raised concerns about the skills required to handle the solar home systems. They indicated that they were not choosy about solar home systems versus on-grid electricity connection, but were more concerned about the replacement of batteries, handling the solar home sets, disposing of the old batteries, and taking care of the solar panels. They also stressed that the solar home sets be provided free of cost to them. They also indicated they would be happier if the government can provide them with an on-grid electricity connection if possible.

Public Consultation at Village Chota Tsirang/Sisty and Daragaon, Geog Sengye, Sarpang Dzongkhag, January 15, 2010

168. Twenty households participated in this public consultation. Participants were concerned about the type of SHS they will be provided (some of them HAD SEEN defective systems elsewhere). They FELT that if the SHS provided do not work, they would prefer AN on-grid connection. The participants also raised concerns about the short supply of electricity during rainy and cloudy days and also the danger of the solar home sets being stolen by the miscreants from across the border in India. Overall, they preferred on-grid electricity connection.

8.4 Responses to Public Concerns

169. The project has tried its best to address the issues raised during the public consultations. A summary of the issues raised and responses/comments is presented in Table H-13.

Table H-13: Issues and Concerns Raised during Public Consultations

Issue/Concern Raised	Responses/Comments Provided
Bhutan is cloudy most of the year, so functioning may be difficult (Issue raised at Dagana)	The consultants checked solar insolation at Dagana dzongkhag and available solar insolation is sufficient for the proposed SHS
Will prefer supply through the grid as it will be more reliable (Issue raised at most of the meetings)	Extension of the grid is not possible on account of techno-economic reasons so SHS are to be installed to achieve 100 % rural electrification by 2013
SHS batteries will be costly and difficult to transport when replacements are needed	The installation of new SHS will be free of cost. The battery life is 3-5 years. Subsequent battery replacement will be made available at rates subsidized by the DOE. The O&M will be provided by BPC village technicians, who will arrange to pick up the used batteries to the nearest BPC customer service center.
Operation and maintenance will be a problem as people have no experience and nor have seen any SHS functioning	The O&M will be provided by BPC village technicians. At the Renewable Energy Department (RED) there will be a full time operation and maintenance manager who will manage the O&M of SHS with the help of BPC village technicians.
Disposal of used batteries and taking care of PV panels will be a problem	The used batteries will be replaced by new ones by BPC village technicians. The used batteries will be transported to nearest BPC customer service center. From there, they will be transported by truck to Phuentsholing for recycling in India.
Some people were apprehensive that defective SHS may be provided and will not work	The RED will procure all SHS with established technical specifications and from a reputable manufacturer providing SHS warranty. The question of defective SHS does not arise.

8.5 Conclusion

170. Based on the above assessment, all concerns of the stakeholders have been taken into account in the project design. The suggestions of institutional stakeholders have also been taken into account through the inception workshop and the circulation of the consultants' deliverables to all concerned departments of the RGOB for review and refinement.

9. GRIEVANCE REDRESS MECHANISM

171. The SHS project does not involve any acquisition of land and there is no generation of emissions, effluents or solid waste. The public complaints on environmental impacts against the project are not anticipated because SHS installation will be in private houses. The DOE will sign a Memorandum of Understanding with the BPC for O&M of SHS in the post-installation phase. Currently BPC has 150 customer service centers across the country. All O&M complaints will be received at these centers either in person or other forms of communication. On receipt of complaints village technicians will attend to them. All issues will be resolved within seven working days. In addition, the RED will have a dedicated SHS O&M Program Manager. The complaints received by BPC customer service centers will also be forwarded to the O&M SHS program manager for his records and analysis. This manager will be the focal person for receiving and resolving any grievances. He or she will resolve the problem within two weeks. The O&M SHS program manager will also be responsible for the EMP's implementation. The RED will follow an open door policy to receive any suggestions to improve the functioning of SHS. These suggestions will also be received at BPC customer service centers and the office of the SHS project at the RED.

10. INSTITUTIONAL REQUIREMENTS, AND ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

10.1 Institutional Requirements

173. The SHS project will be implemented and monitored by the Renewable Energy Division (RED) of the Department of Energy (DOE) of the Ministry of Economic Affairs. As the Implementing Agency, the RED will appoint a full-time SHS O&M Program Manager.

174. The DOE will be the Executing Agency (EA). Responsibility for implementing the Environmental Management Plan (EMP) will lie with the SHS O&M Program Manager. This manager will be appointed by the RED. The DOE will outsource the SHS O&M services to the BPC to be performed by BPC's contracted village technicians.

175. The RED will be responsible for ensuring compliance with the environmental requirements of the ADB and National Environment Commission (NEC). Meeting all reporting requirements will be the responsibility of the SHS O&M Program Manager.

176. The EMP will be a part of the training program RED will provide for village technicians of the BPC. The transporter of used batteries will also be given training on the safe handling and transport of used batteries.

177. All the statutory clearances (at the national, dzongkhag and local levels) required

for the implementation of the SHS project have been obtained in compliance with the national/state/local laws and regulations and in accordance with ADB's *Safeguard Policy Statement 2009*.

10.2 Environment Monitoring Plan

178. To ensure the effective implementation of mitigation measures, it is essential that an Environmental Monitoring Plan be followed. This plan is summarized in Table H-14.

179. The SHS O&M Program Manager will monitor compliance with the EMP and be a Designated Environmental Officer of the SHS project. During the installation phase of SHS, this Manager will train BPC's village technicians and transporter of used batteries.

180. During the operations phase, village technicians will make regular trips to the villages to educate the rural population on simple SHS maintenance. During their visits, these technicians will also check the SHS, including the charging capacity of the battery. The SHS O&M Program Manager will also visit the SHS installed to observe the actual functioning of SHS and talk with villagers. The suggested visit frequency for the O&M manager is quarterly.

10.3 Environmental Management Plan

181. The EMP includes measures for mitigating the negative impacts identified. This plan will also include the location, timeframe, implementation and oversight /supervisory responsibilities for each mitigation measure to be taken.

182. The identified potential impacts and suggested mitigation measures with institutional responsibilities are summarized in Table H-15.

10.4 Environmental Management Plan Cost

183. No environmental issues are anticipated to arise during the installation and operations phases of the SHS project, other than those connected with the collection and transport of used batteries. In the project's first three years, no environmental issue is likely as battery life varies from three to five years. The collection cost of used batteries is included in the project's O&M budget. The time input of SHS O&M Program Manager for the implementation of the EMP has also been included in the O&M budget. Hence, there are no additional EMP compliance costs as these have already been accounted for in the project implementation costs.

Table H-14: Environmental Monitoring Plan						
Environmental Component	**Project stage**	**Parameter**	**Location**	**Duration / Frequency**	**Implementation**	**Supervision**
Handling, transport and safe storage at BPC customer centers of used (non-performing battery) batteries of solar home systems	Operation stage	Leakage of acid and unauthorized disposal by the owner Storage on impervious surface at BPC customer centers	BPC customer service centers and installation sites	During entire life of the SHS project	Village technicians of BPC	The SHS O&M manager at the RED
Collection of used batteries	Operation stage (during transportation of batteries to Phuentsholing)	Leakage	Trucks carrying used batteries	During transport	The SHS O&M manager at the RED	DOE

Table H-15: Environmental Management Plan (EMP)						
Project Stage - Anticipated Environmental Issues and Impacts	**Proposed Mitigation Measures**	**Parameter to be Monitored**	**Measurement Frequency**	**Institutional Responsibility**		**Cost**
				Implementation	**Supervision**	
A. Pre Installation Phase						
1. Formulation of schedule for preventive O&M for installed SHS	BPC village technicians will visit each SHS set at least three times a year to perform preventive and corrective maintenance	Aspects to be observed by technicians including PV panel, accessories, luminaries, wires, strength of battery with multi-meter & other tools.	Not applicable	RED	DOE	Included in the O&M program budget
B. Installation Phase						
1. Disposal of waste materials such as packing materials from installation sites	The packaging materials of SHS should be properly disposed of	Plastic & other packing materials should be disposed at the solid waste disposal sites of dzongkhags	During entire installation period	BPC village technicians	O&M program manager	Included in the O&M program budget

Table H-15: Environmental Management Plan (EMP)						
Project Stage - Anticipated Environmental Issues and Impacts	**Proposed Mitigation Measures**	**Parameter to be Monitored**	**Measurement Frequency**	**Institutional Responsibility**		**Cost**
				Implementation	**Supervision**	
Training for BPC village technicians on 1) the operation and maintenance of SHS and on safe transport of used batteries to customer service centers of BPC and 2) mitigation measures to be taken in the event of acid leakages	The RED will organize a training program for BPC village technicians on SHS operation and maintenance and safe transport to BPC customer service centers. To handle potential leakages of acid, they will be given training to dilute the spilled acid with large quantities of water.	Not applicable	Once during installation phase, annually thereafter	O&M program manager at RED	DOE	Included in O&M program budget
C: Operation Phase						
1. Preventive maintenance of SHS	Preventive maintenance of SHS system	Electrical continuity in wiring, proper orientation of PV panel, strength of battery with multi-meter, luminaries functioning	As per preventive maintenance schedule	BPC village technicians	O&M Program Manager	Included in the O&M budget
2 Safe collection of used batteries	Village technicians will arrange to transport the used batteries by hiring local labor to the nearest BPC customer service center. Collected used batteries will be stored on impervious surface.	Ensure that there is no leakage of acid from the used batteries while they are being transported	Transport of used batteries on need basis	The SHS O&M Program Manager at the RED	DOE	Included in the O&M budget

Table H-15: Environmental Management Plan (EMP)						
Project Stage - Anticipated Environmental Issues and Impacts	**Proposed Mitigation Measures**	**Parameter to be Monitored**	**Measurement Frequency**	**Institutional Responsibility**		**Cost**
				Implementation	**Supervision**	
	On the basis of the number of used batteries stored at customer service centers, the O&M manager will arrange a truck to pick up these batteries for transportation to Phuentsholing for onward transportation to authorized battery recyclers to India. The DOE will appoint a contractor for this task. The transporter will be trained to neutralize accidentally leaked acid with large quantities of water.	Leaked acid	During transport	Transporter	O&M Program Manager	Included in the O&M budget

11. FINDINGS, RECOMMENDATIONS, AND CONCLUSION

11.1 Findings

184. The findings of the IEE are as follows:

- The SHS project is environmentally friendly and it will help achieve the RGOB target of providing electricity to all by 2013. It will help electrify the households in remote isolated villages where grid extension is not feasible.

- The only potential environmental impact identified is related to the collection and transport of used batteries. For this, an EMP has been prepared. There will be no short- or long-term adverse impacts on the environment during installation and operations phases.

- The quality of life of the beneficiary households will improve and the project will help bring prosperity. There will be direct and indirect generation of employment due to the project.

- Mitigation and monitoring measures have been developed in the EMP. The EMP will be implemented by the O&M Program Manager at the RED, and monitored and enforced by regulatory agencies and ADB. Public consultations have been undertaken during the project preparation. The RED will follow an open door policy for receiving complaints, if any, from the concerned households, and will conduct additional consultations as necessary during the project's implementation.

11.2 Recommendations

185. A memorandum of understanding should be signed between the BPC and the DOE for SHS O&M to be performed by the BPC village technicians

186. A training program should be organised during the installation phase by the DOE for village technicians on SHS operation and maintenance and safe transport of used batteries to BPC customer service centers.

187. A training program should also be organized for transporters involved in the collection and transport of used batteries during the operations phase.

11.3 Conclusion

188. The SHS project will not result in any long-term significant adverse environmental impacts. The likely negative impacts will be avoided through the safe collection and transport of used batteries from BPC Customer Service Centers to Phuentsholing, where they will be turned over to licensed recycling agents in India. Environmental and social benefits of the project and long-term investment program objectives outweigh the negative impacts.

189. Based on the environmental assessment activities conducted to date, the project is confirmed as environmental category B and the IEE, including the EMP, is considered sufficient to meet the environmental assessment requirements of ADB and the RGOB. A full environmental impact assessment study is not required.

Appendix I

INITIAL ENVIRONMENTAL EXAMINATION FOR THE WIND POWER PILOT PROJECT COMPONENT

1. EXECUTIVE SUMMARY

1. Bhutan's power generation system relies heavily on run-of-river hydropower plants whose generation capacity is drastically reduced in the winter dry season due to reduced water flows in rivers. As a result, the existing power generation system has been unable to meet fast growing demands in the winter peak period, and for the last few years the Bhutan Power Corporation (BPC) has been shedding industrial loads. The peak power demand is expected to exceed supply by some 20 MW in the winter of 2010 and this demand / supply gap in the peak demand winter period is expected to continue for several more years until new hydropower stations come on line.

2. **Project Objectives.** The project will pilot test wind power technology to: 1) gain experience in the construction and operation of wind farms and 2) collect additional wind data to improve estimates of the potential for producing wind power to help alleviate power shortages in the winter peak demand period. The proposed pilot project will support the RGOB's strategy to diversify energy resources, enhance long-term energy security, and generate additional power to meet the growing peak demand in the winter.

3. **Project Location.** The wind power pilot project is planned to be established at Tsimalakha village in Bijcho Gewog in Chukha dzongkhag. The latitude and longitude of the site are 27 degrees North and 89 degrees East, respectively. The distance from the dzongkhag administration office is about 4.5 km.

4. **Initial Environmental Examination (IEE).** The IEE report was prepared in accordance with ADB's *Safeguard Policy Statement 2009*. The IEE preparation led to the identification of potential environmental impacts during the construction and operations phases and the preparation of an Environmental Management Plan (EMP) to mitigate the negative impacts identified.

5. **Project Category.** The wind power pilot project has been classified as Safeguard Category B for environment and involuntary resettlement, as there are no significant impacts during the construction and operations phases.

6. **Project Brief Details.** The proposed wind power pilot project consists of: 1) the construction and operation of two 180 kW pilot wind turbines at the Tsimalakha site in Chukha dzongkhag and 2) the installation of wind (measurement) masts at three additional sites. The key data of the pilot project at Tsimalakha site are shown in Table I-1.

Table I-1: Key Components of the Wind Power Pilot Project		
S. No.	**Component**	**Quantity**
Element		
	Wind Turbine	
1	Unit capacity of the wind turbines	180 kW
2	Number of wind turbines	2
3	Total generation capacity	360 kW
4	Hub height	31 meters
5	Turbine blade length	11 meters
6	Number of blades per turbine	2
7	Total land area required	
	(a) Permanent use (foundation)	81 m^2
	(b) Temporary uses (during construction)	300 m^2
Wind Mast		
1	Height	20 meters
2	Number of wind masts	1
Access Road		
1	Access road from existing road to site	800 m x 5 m
Grid Connection to 11 kV Line		
1	Connection line to power grid	163 m

7. **Implementing and Executing Agencies.** The Department of Energy (DOE) of the Ministry of Economic Affairs (MOEA) will be the Executing Agency (EA), and the BPC will be the Implementing Agency (IA).

8. **Policy, Legal and Administrative Framework**. In Bhutan environmental protection has been entrusted to the NEC. The Royal Government of Bhutan has enacted a number of acts and rules such as the Forest and Nature Conservation Act 1995, Forest and Nature Conservation Rules 2000, and Environmental Assessment Act 2000. For the wind power pilot project the Land Acquisition Act 1979 will be applicable as land acquisition will be required for the 800 meter long access road. The project will support the Electrification Act 2001, as there electricity will be generated from the wind, a renewable source. The wind power pilot project does not require environmental clearance as it is not included in the government's list of industries/activities

requiring environmental clearance. But on the advice of the NEC, an environmental clearance application containing the project profile, impacts, mitigations, and an environmental management plan was prepared and submitted to the NEC. The NEC subsequently issued an environmental clearance exemption for the proposed project.

1.1 Description of the Environment

Physical Environment

9. The determination of baseline conditions is a pre-requirement in the preparation of IEE reports. The prevailing baseline status in the project area is summarized below.

10. **Topography, Geology and Soil.** Chukha dzongkhag, where the wind power pilot project is proposed to be installed, is located in southwestern Bhutan and shares its borders with the dzongkhags of Dagana to the east, Samtse and Haa to the west, Paro and Thimphu to the north, and the Indian State of West Bengal to the south. The total geographical area of Chukha dzongkhag is 1,882 square km. The total geographical area of the country is 38,394 square km. The elevation of the project site is 2,200 m above sea level.

11. The project site falls within the Lesser Himalayan formation. This includes a wide range of sedimentary and low-grade metamorphic rocks, including argillites and metargillites, sandstones and quartzite, limestone, dolomite and gypsum. Gneisses underlie in the entire dzongkhag almost to the Indian border.

12. The soil type in the project site is clayey loam. The soil color is blackish. No agriculture activity was seen near the project site. The soils near Wong Chu are sandy loam in texture. At the site soils are shallow as there is stone grit underneath. The soils are alkaline in nature.

13. **Climate and Meteorology**. The climate at the project site and its surroundings is cool and temperate, with warm humid summers and chilly winters with snowfall. At the project site, strong winds have been observed.

14. The relative humidity in the project area ranges from 63% to 90%, with an average of about 70%. The least-humid period is during the pre-monsoon (March-May). The average mean temperature for the warmest months of June and July is about 20° C to 30° C, while the mean temperature for the coldest months of January and February is about 10° C to 12° C. Snow falls occasionally at the project site, while in January and December, temperatures can go below 0° C.

15. The average rainfall in the project area is around 1,000 mm, but sometimes the precipitation becomes much heavier. Precipitation is heaviest between June and September.

16. **Ambient Air Quality.** No ambient air quality data are available for the project area. As

the project area has characteristics similar to Thimphu with respect of terrain and topography, the published ambient air quality data for Thimphu were analyzed to provide some reference information. The measured carbon monoxide (CO), nitrogen oxides (NO_x), and particulate matter (PM_{10}) concentrations in Thimphu are 7.14 mg/m^3, 10.49 ug/m^3, and 24.5 ug/m^3, respectively, which are much lower than the ambient standards of these pollutants recommended by the World Health Organization. Even better ambient air quality is expected at the project site, where the population is much lower, as are construction and commercial activities and vehicles. Thus, ambient air quality is not a concern at the project site and surroundings.

17. **Surface Water Resource and Quality.** During the monsoon, heavy rains often cause flash floods in the valleys, which are very vulnerable to erosion due to the cultivation of land. The construction of embankments in the erosion prone-areas and river diversion are being undertaken as protective measures. Surface water quality data for the project area are not available, but the rivers are considered to be pristine as there are no pollution discharge sources upstream of the project site.

18. **Groundwater Resource and Quality.** There are no groundwater data available for the project area. Groundwater resources are abundant, with springs emerging from underground rocks, old landslides and fluvial deposits. Groundwater in landslide and alluvial deposits has been estimated at an exploitable rate of 3 liters per second per km^2. Currently, water quality monitoring is only conducted in the four major river systems of Bhutan. Generally, Bhutan's groundwater quality is still good, but with expanding settlement along rivers, there are localized pollution problems. In the project area, water quality is anticipated to be good.

19. **Noise Level.** Noise is an important environmental attribute for a wind power project as noise is generated from wind turbines. No noise measurement data are available for the site and surroundings (currently, the NEC is measuring noise levels at Phuentsholing and Thimphu only). Major contributors to ambient noise are commercial and industrial activities and vehicular traffic. At the project site and surroundings noise is expected to be within the stipulated limits of the NEC for rural and residential areas (55 dB(A) at day time, and 45 dB(A) at night time). This is because there are few commercial activities and little vehicular traffic around the project site.

20. **Aquatic Environment.** There are 41 species of fish in the rivers and lakes of Bhutan. This includes eight exotic species like the coldwater trout, and other species introduced for warm water aquaculture. These types of species are expected to be found in the Wongchu River.

Ecological Resources

21. **Protected Areas.** There is no protected area in Chukha dzongkhag. The nearest protected area to the project site is Jigme Singye Wangchuk National Park (JSWNP), about 50 km from the project site.

22. **Habitat and Flora in the Project Area and Surroundings.** The Chukha dzongkhag has 82.39 % of its geographical area under forests. The dominant type of forests in the project area and its surroundings is broadleaf forest. There is no forest at the project site.

23. The project site is not a habitat to any endangered species of fauna. The project area and surroundings have domesticated fauna.

24. **Biodiversity.** In forest areas of Chukha dzongkhag, broadleaf forest is dominant, at about 60%. The second dominant category of forest is mixed conifer forest. The forests in the protected areas mainly comprise subtropical forests, warm broadleaved forest and cool broadleaved forests.

25. The project area and surroundings have 9 species of animals and 15 species of birds. None of these species of flora and fauna is endangered or protected.

Economic Development Resources

26. **Land Use, Industries and Agriculture.** Land use at the project site is institutional as the land is in the possession of Bhutan Power Corporation. BPC has aborted its plan to develop a training institute and currently has no specific plan for the site. The land use of the proposed access road to the project site is barren private land. The predominant land use of Chukha dzongkhag is forest (82.39%), followed by cultivation (9%), pasture (4%), and settlement (0.3%). The balance is in water bodies and rocky area.

27. The major crops produced in Chukha dzongkhag include orange, potato, and cardamom. Livestock rearing is a major occupation and provides opportunities for processing and trading in dairy products such as butter, cheese and milk because of the availability of ready markets.

28. Chukha dzongkhag is endowed with tremendous economic opportunities as it has two special economic zones: Phuentsholing as a principal commercial center and Pasakha as an industrial estate. The presence of two mega hydropower projects in the dzongkhag is another significant positive point. These two projects are Chukha Hydro Power and Tala Hydro Power. As a result Chukha is the highest revenue generating dzongkhag in the country. The Chukha project is around 5 km from the wind power pilot project site. There is no industry in the immediate surroundings of the project site.

29. **Administrative Infrastructure and Community Facilities.** The dzongkhag administrative offices at Chukha include revenue, land, forest, livestock, planning, and other offices. Chukha town has amenities such as bank, post office and communication centers.

30. The Chukha dzongkhag has 17 community primary schools, 4 primary schools, 7 lower secondary schools, 5 middle secondary schools, 3 higher secondary schools, and 33 non-formal education centers. The total number of students in these schools is 14,794. The literacy rate in the dzongkhag is 63.1%. Its health facilities include 3 hospitals, 9 basic health units, and 28

outreach clinics. Chukha dzongkhag has 3 renewable energy resources centers, 6 agriculture extension centers, 1 veterinary hospital, 6 livestock centers, and 2 forestry extension centers.

31. **Transportation.** There are good transportation facilities in Chukha dzongkhag. Its national highway stretches for 223 km, feeder road length for 206 km, farm road length for 28.4 km and power tiller track for 17 km. The Tsimalakha village near the project site is connected by a 5.5 m wide bituminous road.

32. **Electricity and Communication.** The households close to the dzongkhag headquarters have been electrified. Based on the information available from Chukha dzongkhag administrative office, the number of households electrified is 10,323. The electrification percentage of rural households is around 70%.

33. In Chukha dzongkhag there are 3,979 fixed-line telephones, 368 rural communication facilities, 4 post offices, and 15 bridges/suspension bridges.

34. **Water Supply and Sanitation.** In Chukha dzongkhag there are 199 water supply schemes. The percentage of households having rural water supply is 62%. In the dzongkhag the number of households having toilets/latrines is 5,832.

35. **Tourism.** Currently there is no important tourist destination in the dzongkhag.

Social and Cultural Resources

36. **Demography.** The population of Bhutan includes many ethnic groups such as the Sharchops in the east, Ngalongs in the west, Khengpas in the central region, nomads in the north and Lhotshampas in the south. Some of these ethnic groups are also found in Chukha dzongkhag. Because of the mix of ethnicities, a wide variety of dialects is spoken, of which Dzongkha, Khengkha, Sharchop and various dialects of Nepali are the most common. The majority of the population are Buddhist (around 70%) and the remainder are mainly Hindu, mostly in the southern areas.

37. The population of Chukha dzongkhag is 74,387. The dzongkhag has a sex (male to female) ratio of 1:1. In the dzongkhag about 68% of the population is rural residents, while 32% is urban dwellers. The average number of family members per household is 4.56.

38. **History and Cultural.** Chukha dzongkhag was established in 1987, coinciding with the beginning of the sixth Five Year Plan. The dzongkhag has government owned public as well as private Lahakhangs.

39. In Bhutan traditions are followed religiously. The male and female traditional dresses are Kho and Kira. The same dresses are also worn in Chukha dzongkhag.

40. In Chukha dzongkhag there are no culturally significant structures. Most of the larger

villages have a temple, and there are smaller Buddhist shrines both inside and outside inhabited areas. There are also other places or objects that are of significance to the community, including particular trees, river and other locations.

1.2 Environmental Impacts and Mitigation Measures

41. No impacts from the proposed pilot project's construction or operation have been identified on protected areas, as the nearest National Park JSWNP is 50 km from the project site. The other environmental attributes where no impacts from the project have been identified are:

- Physical Resources: Geology, climate and meteorology, and groundwater resources and quality
- Ecological Resources: Protected areas, forests
- Economic Development Resources: Tourism, industry and agriculture
- Social and Cultural Resources: History and culture.

42. The impact identified on topography in the project area and surroundings during construction is due to the construction of the access road, installation of wind mast, wind turbines, electric substation and grid connection. These changes will be permanent.

43. Four land owners will be affected by the loss of a portion of their land (less than 10% of their land holdings) due to construction of the access road to the project site, and one land owner by the need for a right of way for the grid connection line. All the four landowners have agreed to give their land to the access road, and the fifth owner has agreed to provide the needed right of way. The government will provide the affected landowners with substitute land of their preference in Chukha dzongkhag per the Bhutan Land Act and ADB *Safeguard Policy Statement 2009*.

44. Dust will be generated as a result of the movement of construction vehicles and machinery at the project and access road construction sites. Noise will also be generated at construction site(s) due to construction activities. These impacts will be limited during the construction phase, which will last three or four months.

45. No adverse impact has been identified on the biodiversity of the project area. No cutting of trees will be required for the project. The only minor impact identified is when birds accidentally fluy into the blades of wind turbines. This would be rare as there are no known bird migration paths in Chukha dzongkhag.

46. The impact identified during operations phase is noise due to the movement of the blades and humming sound of the wind turbines (low frequency noise). The nearest house to the wind turbine site is about 250 m to the southeast; Tsimalakha village is over 0.8 km away to the northwest. The noise level contours provided by the turbine manufacturer indicate that the noise levels at 200 m or more away from the wind turbines will be well within the limits prescribed by the NEC for rural/residential areas.

47. In order to mitigate negative environmental impacts during construction, no construction work or transport of construction materials will be carried out at night. Water will be spread regularly to reduce dust generation during construction. If the construction manager feels that there is excessive noise due to construction activity, the manager will be directed to use portable noise barriers. Temporary drainage will be provided at the construction site for storm water runoff. Adequate cross-drainage structures will be provided at the access road for effective drainage. The contractor will properly fence the construction site for the safety of both people and animals. No construction wastes will be disposed of in any water body. To the extent possible, these wastes will be used as embankment fill. The contractor will provide personal protective equipment to all staff and workers for their safety. At the construction camp there will be proper sanitation arrangements (septic tank/soak pit) and filtered drinking water supply. The workers will be trained not to hunt animals and not to cut trees for firewood/cooking.

48. In the operations phase noise will be measured at Tsimalakha village and the nearest house. If noise levels are found to exceed the levels prescribed by the NEC for rural/residential areas, mitigation measures in the form of green belt development on the eastern boundary of the wind turbine site and a noise barrier wall on the north, south, and west sides of the site will be erected. There will be no impact on the health of local residents, including those living in the nearest house due to the low frequency noise. If this is not the case, additional mitigations will be planned.

49. Shrubs will be planted on the side slopes of the access road to avoid soil erosion. Drains will be properly maintained at the project site and access road.

50. The project design will ensure that the access road, wind turbines and electrical equipment foundations are earthquake resistant. The turbines will have a safety design to enable turbine the blades to stop moving automatically when wind speeds exceed 25 m/s to avoid storm damage.

1.3 Analysis of Alternatives

51. Three possible alternatives were analyzed (see Table I-2).

Table I-2: Analysis of Alternatives

Parameters	No Project Scenario	Project Scenario	Other Forms of Energy Scenario (coal- or biomass-fired power plants)
Economic cost	This scenario will be cheaper as there will be no investment cost for wind power	This scenario will require investment and the economic cost may be higher	High cost and may not be feasible to install due to terrain and techno-economic reasons

Table I-2: Analysis of Alternatives			
Parameters	**No Project Scenario**	**Project Scenario**	**Other Forms of Energy Scenario (coal- or biomass-fired power plants)**
	Load shedding in the winter dry seasons will continue	No impact on the country's balance account as the pilot project is funded by an ADB grant	There will be a high coal import cost as there is little coal reserve in the country.
Developmental impacts and people's perceptions	Economic development in the country will be slow because of load shedding	Load shedding will be reduced, resulting in increased economic development of country	Coal- and biomass-based power plants are not feasible; therefore, load shedding will continue resulting, in slow economic development
Social benefits	Fewer employment opportunities due to the curtailment of industrial development resulting from power shortages in the winter	Clean and renewable energy This will help in the electrification of rural households to achieve the government's target of Electricity for All by 2013 There will be a better quality of life of the electrified rural poor	No social benefits as the collection of biomass from forests will worsen deforestation in the country
Environmental impacts	Will have no incremental benefits as the project scenario does not generate any environmental losses such as tree cutting, air pollution or water pollution	No environmental impacts as noise levels are likely to be within the national standards beyond 200 m from the project site	Coal- and biomass-fired power plants will result in huge air pollution and solid waste problems
Health	No impact on health	Noise impact unlikely, planned mitigating measures will be implemented if the actual noise levels exceed the national standard	Adverse impacts on health due to high levels of air pollution from coal- and biomass-fired power plants

52. Based on the above comparison of the three alternatives, the project alternative is the best choice for the development of energy resources in Bhutan.

1.4 Public Consultations and Information Disclosure

53. Public consultations have been carried out since inception stage of the project to disseminate the information and seek inputs about the project. The consultations were carried out at the institutional, local and dzongkhag levels, as shown in Table I-3.

Table I-3: Summary of Public Consultations

S. No.	Date of Consultation	Level	Organizations/ Public	Objectives
01	03-12-2009	Inception workshop by PPTA consultants	NEC, BPC, DOE, Ministry of Economic Affairs, Ministry of Finance, JICA, ADB	To invite views, comments and suggestions on the project
02	08-12-2009, 19-03-2010 and 10-05-2010	Institutional	NEC for environmental clearance of the project, BPC for grid connection	To obtain environmental clearance and grid connection for the project
03	17-12-2009 and 26-03-2010	Dzongkhag Level	Chukha dzongkhag head and land record officer for wind power site at Tsimalakha	To explore the possibility of obtaining the dzongkhag head's agreement for the wind power pilot project at Tsimalakha
04	16-12-2009	Local level	Gup of Tsimalakha, land owners of access road and land record officer	To inform the public and project affected persons about the project and invite their comments and suggestions on project design
05	26-03-2010	Local level	Gup of Tsimalakha, land owners of access road and land record officer	To inform the public about the project and invite their comments and suggestions for incorporation in project design

54. The comments, suggestions and concerns of public and how they were addressed are shown in Table I-4.

Table I-4: Summary of Public Responses	
Issue/Concern Raised	**Responses/Comments Provided**
Locally grown trees should be planted at the project site and on the side slopes of access road	Locally grown trees, in consultation with the Forest Department, will be planted on the eastern boundary of the project site to reduce noise levels at the nearest house
There is frequent storm run-off during the monsoon and proper drainage arrangements at the project site and at access road should be established	Adequate cross-drainage structures in the access road and proper drainage arrangements at the project site will be provided.
Water spraying should be carried out to suppress construction dust, and construction activity should not be carried out at night	The consultants and DOE gave assurances that the necessary conditions will be put in the contract so that there is no construction activity or transportation of construction materials at night. Measures to mitigate construction impacts will also be included in the EMP.

55. At the institutional-level consultations, all participants welcomed the project as it will provide clean and renewable energy and will help reduce power shortages in the winter months.

1.5 Grievance Redness Mechanism

56. No major environmental issues associated with the wind power pilot project have been identified. Hence, no complaints related to the environment are anticipated. To address any unforeseen environmental issues during construction and operation, BPC has formulated a grievance redress mechanism to resolve complaints. It will establish a Project Implementation Unit (PIU) with a full-time manager to implement the wind power pilot project. The PIU manager will also be responsible for the implementation of the EMP. During the construction phase a complaint register will be available in the on-site construction office. It will be accessible to the public. Any complaint received will be resolved by the PIU within seven days.

57. It is expected that the BPC will also appoint qualified engineers to operate and maintain the wind power pilot project. The operator will be stationed at Chukha/Tsimalakha. The complaint register will be available at the project operator's office. Any complaint received will be resolved by the project operator. In case the project operator is not able to resolve the complaint, the PIU manager will provide backup support to resolve the complaint. The Environmental Management Plan's implementation will be part of the project operator's terms of reference, and EMP costs will be part of the operations budget. The BPC will adopt an open door policy to receive any suggestions for better management and operation of the project.

1.6 Environmental Management Plan

58. The EMP includes specific measures to mitigate the identified negative impacts. The EMP includes the location, timeframe, implementation and oversight/supervisory responsibilities for each mitigation measure to be taken.

59. The EMP cost for the wind power pilot project has been estimated at $25,000.

1.7 Findings, Recommendations, and Conclusion

60. **Findings.** The findings are as follows:

- The wind power pilot project will help diversify energy resources and enhance Bhutan’s long-term energy security. It will help reduce winter power shortages for the next several years.

- The construction impacts identified will be temporary and will be limited to the three to four-month construction period and will be effectively mitigated by the measures included in the EMP.

- The potential environmental impact during operations identified is noise generation. The nearest house is located 250 m northeast of the project site. The ambient noise levels will be within the stipulated limits of the NEC at this house. No impact on the ambient noise level at Tsimalakha village is anticipated.

Recommendations

61. A green belt development to the east of the site is recommended to attenuate noise levels at the nearest house.

62. Noise level measurements will be carried out at Tsimalakha village and the nearest house during the operations phase. In case actual noise levels exceed the standards, then noise barriers will be erected on three sides of the nearest house and tall trees will be planted along the eastern boundary of the project site. After these mitigating measures are implemented, noise levels will be monitored to determine their adequacy. The PIU will also observe any impacts on health due to the operation of the wind power pilot project.

63. The PIU manager will ensure that no construction activities or transport of construction materials occur at night.

Conclusion

64. The wind power pilot project will not result in any long-term significant adverse

environmental impacts. The implementation of the EMP will ensure that all environmental impacts will be within acceptable levels.

65. Based on the environmental assessment of activities conducted to date, the project is confirmed as Safeguard Category B for environment and involuntary resettlement, and the IEE, including the EMP, is considered sufficient to meet the environmental assessment requirements of ADB and the RGOB. A full environmental impact assessment study is not required.

2. INTRODUCTION

66. Bhutan's power generation system relies heavily on run-of-river hydropower plants whose generation capacity is drastically reduced in the winter dry season due to reduced water flows in rivers. As a result, the existing power generation system has been unable to meet fast growing demands in the winter peak period, and for the last few years the Bhutan Power Corporation (BPC) has been shedding industrial loads. The peak power demand is expected to exceed supply by some 20 MW in the winter of 2010 and this demand / supply gap in the peak demand winter period is expected to continue for several more years until new hydropower stations come on line.

67. The objectives of the project are to pilot test wind power technology to: 1) learn about the construction and operation of wind farms and 2) collect additional wind data to help determine the potential for producing wind power to alleviate power shortages in the winter peak demand period. The proposed pilot project will support the RGOB's strategy to diversify energy resources, enhance long-term energy security, and generate additional power to meet the growing peak demand in the winter.

68. The Department of Energy (DOE) of the Ministry of Economic Affairs (MOEA) will be the Executing Agency (EA) and the Bhutan Power Corporation (BPC) will be the Implementing Agency (IA).

2.1 Initial Environmental Examination

69. The Initial Environmental Examination (IEE) was carried out to identify and assess the potential environmental impacts from implementing the wind power pilot project at Tsimalakha in Chukha dzongkhag. The components of wind power pilot project include 1) wind turbines, 2) wind mast, 3) access road and 4) connection to the power grid. The BPC has agreed to give seven acres of land to the proposed wind power pilot project. Four land owners have agreed to give a portion of their land for the construction of the access road, and one land owner has agreed to provide the right of way for the overhead grid connection line. The government will provide substitute land within Chukha dzongkhag in accordance with the

Bhutan Land Act and ADB's *Safeguard Policy Statement 2009*. The current RGOB environmental legislation does not require an environmental impact assessment study and environmental clearance for the implementation of wind power pilot projects. However, per the advice of the NEC, the DOE prepared and submitted an environmental clearance application to the NEC, and the NEC subsequently issued an environmental clearance for the proposed wind power pilot project. The project has been classified as Safeguard Category B based on the rapid environmental assessment prepared in accordance with ADB's *Environmental Assessment Guidelines* (2003) and *Safeguard Policy Statement 2009*. This IEE report was prepared in accordance with ADB *Safeguard Policy Statement 2009* with due consideration to environmental legislation of the ROGB.

70. The IEE was prepared to meet the following objectives:

- To provide information about the general environmental settings at the wind power pilot project site and its surroundings
- To provide information on the potential impacts of the proposed wind power pilot project and characteristic of its impacts: magnitude, distribution, and duration
- To provide information on potential mitigation measures to minimize the impacts
- To provide information on the EMP to mitigate the identified negative impacts due of the project
- To meet the ADB requirements for the wind power pilot project financing.

71. Field visits were made to collect the requisite information for the preparation of the IEE from various government departments and other secondary sources (including public consultations).

2.2 Structure of IEE Report

72. The IEE report is divided in to ten chapters. The coverage of each chapter is summarized below:

- Chapter 1 describes the general background of the project and the requirements and objectives of the IEE.
- Chapter 2 reviews the policy, legal and administrative frameworks relevant to the project. It describes the acts and rules promulgated by the RGOB and their applicability to the project.
- Chapter 3 presents brief technical details on the wind power pilot project, estimated cost and implementing and executing agencies.
- Chapter 4 describes the environmental baselines of the project site and its surroundings.
- Chapter 5 addresses potential environmental impacts and mitigation measures during the construction and operations phases.
- Chapter 6 covers the analysis of alternatives. Alternatives of the project are analyzed

on cost, environmental and socio-economic considerations.

- Chapter 7 summarizes public consultations and information disclosure. The public views, suggestions and opinions and how they were addressed are covered.
- Chapter 8 describes grievance redress mechanisms for the project. How, who and when public complaints will be resolved are summarized.
- Chapter 9 describes the project's institutional arrangements and EMP.
- Chapter-10 summarizes the findings, recommendations, and conclusion of the IEE study.

2.3 Acknowledgements

73. The PPTA consultants gratefully acknowledge the cooperation received from DOE, BPC, NEC, MOEA, Ministry of Agriculture and Forests, JICA and Chukha Dzongdag and its officers. The consultants will also like to thank Mr. K. Ogino, Senior Energy Specialist, Mr. H. Kobayashi, Senior Energy Specialist, Mr. S. Sasaki, Environmental Specialist, Mr. S. Parwez, Programs/Project Implementation Officer, and Ms. P. Van Houten-Castillo of ADB, for their cooperation and guidance.

3. POLICY, LEGAL & ADMINISTRATIVE FRAMEWORK

74. The RGOB has enacted a number of Acts and Rules to safeguard the country's environment. These Acts and Rules and their applicability to the wind power pilot project are summarized in the following subsections.

3.1 Electrification Act 2001

75. Rural electrification is strongly promoted in the Electricity Act, 2001. Part 7, Section 61.1 states that "The Minister shall undertake to promote, support and provide rural electrification programmes through public and private sector participation in order to:

- achieve equitable regional distribution and access to electricity;
- maximize the economic, social and environmental benefits of rural electrification subsidies;
- promote extension of the grid and development of off-grid electrification;
- promote renewable energy."

76. The wind power pilot project will help meet the aim of the Act to achieve equitable regional distribution and access to electricity and promotion of renewal energy.

3.2 Forest and Nature Conservation Act (FNCA) 1995

77. The Forest Act (1969) was the first environmental legislation in Bhutan and brought all forest resources under government custody to regulate utilization. This was repealed with the enactment of the FNCA in 1995, which allows community stewardship of forests, and aims to provide protection and sustainable use of forests, wildlife, and related natural resources. Schedule I lists those wild animals and plants that are given full protection under the Act. None of the trees listed in Schedule 1 exists at the wind power pilot project site. The FNCA establishes that all forests in Bhutan are Government Reserved Forests (GRF), and prohibits any development activity in these areas except with a permit. This Act will not be applicable to the wind power pilot project.

3.3 Forest and Nature Conservation Rules (FNCR) 2000:

78. Under the powers established by the FNCA, the Ministry of Agriculture promulgated the FNCR in 2000, which was revised in 2006. Amongst other things the FNCR allows for:

- Allotment of land and land rights in GRF
- Prohibitions, restrictions and concessions in GRF
- Transport and trade of forest produce
- Declaration and administration of protected areas
- Protection of wildlife and use of certain wild species
- Prevention of forest fires, land clearance, and activities potentially impacting soil, water and wildlife resources
- Enforcing penalties for offences related to these and other aspects of the FNCR.

79. None of these activities likely to be taken up in the wind power pilot project; therefore, this act will not be applicable.

3.4 Protected Areas

80. Since 2008, five National Parks, four Wildlife Sanctuaries and one Strict Nature Reserve have been established in Bhutan. The RGOB's policies require that all proposed development projects within the boundaries of the protected area be subject to an EIA under the jurisdiction of the NEC. This initially included buffer zones outside the protected areas, but was extended to include Biological Corridors in 2006 by an addendum to the FNCR.

81. Biological Corridors (BC) are defined as "areas set aside to connect one or more protected areas, which shall be conserved and managed for the safe movement of wildlife." Although BCs do not have the same status as protected areas, activities such as new settlements, quarrying,

mining, and leasing of land for grazing are prohibited. All other development activities, including construction of roads, electricity transmission and distribution lines, or any other structures, require a permit from the DOF and an EC application to the NEC, supported by an EIA.

82. The proposed wind power project is outside the protected areas and BCs. Thus, no impacts on these protected areas and BCs are expected. The site is 50 km from the nearest protected area (JSWNP).

3.5 Land Act 1979 (Revised 2007)

83. The Land Act 1979, which provides the basis for land tenure in Bhutan, was revised in 2007 to streamline its provisions. One major change was the establishment of an autonomous National Land Commission Secretariat that has been given full responsibility for all matters pertaining to land registration. Also the 20 land categories have been reduced to 7 in the revised Act including 1) *chhuzhing* (wetland), 2) *kamzhing* (dry land) including orchards, 3) *khimsa* (residential land), 4) industrial land, 5) commercial land, 6) recreational, and 7) institutional land.

84. Powers over land management have now been decentralized to local authorities like the Gewog Tshogdue, dzongkhag Tshogdue, and Thromdes. They are empowered to resolve land disputes and endorse land transactions and the conversion of land categories.

85. Under this Act, there are provisions for the acquisition of 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 depending on the land classification as per the prevailing land compensation rate determined by the Act. If a house is acquired, compensation is paid on the basis of an evaluation carried out by a qualified engineer appointed by the competent authority. This Act will not be applicable to the land for the project site as it will be transferred from the BPC to the DOE.

3.6 RGOB Decentralization Policy 2002

86. The Dzongkhag and Gewog Yargay Tshogdue Acts were implemented in 2002 to support the government's decentralization policy and empower locally elected community bodies (DYTs and GYTs) with the authority and responsibility to plan and implement development programs and activities, including those related to environmental management. Through this legislation the DYT is able to:

- Make recommendations on activities with major environmental impacts
- Designate and protect sites and monuments of cultural or historical interest

- Designate and protect areas of special scenic beauty or biodiversity, such as dzongkhag parks and sanctuaries
- Establish and enforce regulations to control noise pollution
- Prohibit the construction of structures within 50 ft of highways.

The GYT is able to establish and enforce regulations to:

- Control and prevent the pollution of air, soil and water
- Ensure safe disposal of waste and adequate standards of sanitation
- Conserve and protect water resources, including rivers, streams, springs and lakes.

The GYT also has custody of communal lands and community forests and can prevent encroachment onto lands and forests.

87. This policy will be triggered because noise will be generated by the project's wind turbines.

3.7 RGOB Environmental Clearance Procedure*s*

Environmental Classification

88. The NEC decides the environmental classification of projects on receiving the Environmental Clearance (EC) application submitted by the project proponent. There are three possible outcomes:

- The NEC may grant Environmental Clearance on the basis of the EC application if the application contains sufficient information and based on information submitted it is concluded that the proposed development will not have significant negative environmental impacts

- The NEC may deny Environmental Clearance on the basis of the EC application if the application contains insufficient information and it is clear that the proposed development will have significant negative environmental impacts that cannot be suitably mitigated

- If the EC application contains insufficient information on the likely nature and extent of the environmental impacts of the project or the manner in which they will be mitigated, the NEC will determine that an EIA is required.

3.8 Preparation of an EC Application

89. The requirements of the EC application are set forth in the sectoral guidelines that were revised with ADB assistance in 2006. The installation of SHS is not included in the government's list of activities requiring environmental clearance.

90. The information required for environmental clearance is very specific, and in all cases includes information on the applicant, the project, funding agency, the affected environment, potential impacts, mitigation, monitoring and public consultation.

91. There are three key elements of the EC application. These include the provision of signed No Objection Certificates (NOC) from all affected stakeholders/households, forestry clearance from the Department of Forests, and dzongkhag administrative approval.

3.10 Conclusion

92. Based on the above reviews, the Land Act 1979 (Revised 2007) and the RGOB Decentralization Policy are directly applicable to the wind power pilot project. The pilot is not included in the NEC's list of activities requiring environmental clearance. However, a series of discussions have been held with the NEC and based on the, DOC submitted an EC application. The NEC subsequently issued an EC for the proposed wind power pilot project.

4. PROJECT DESCRIPTION

4.1 Need for the Project

93. There is shortage of power in Bhutan during the winter. This shortage is due to lower amounts of power being generated from the existing run-of-river hydropower plants. At present, the country is dependent exclusively on run-of-river hydroelectric power generation. To help reduce the winter power shortages and explore other renewable sources, this wind power pilot project is planned near Tsimalakha village in Chukha Dzongkhag.

4.2 Objectives

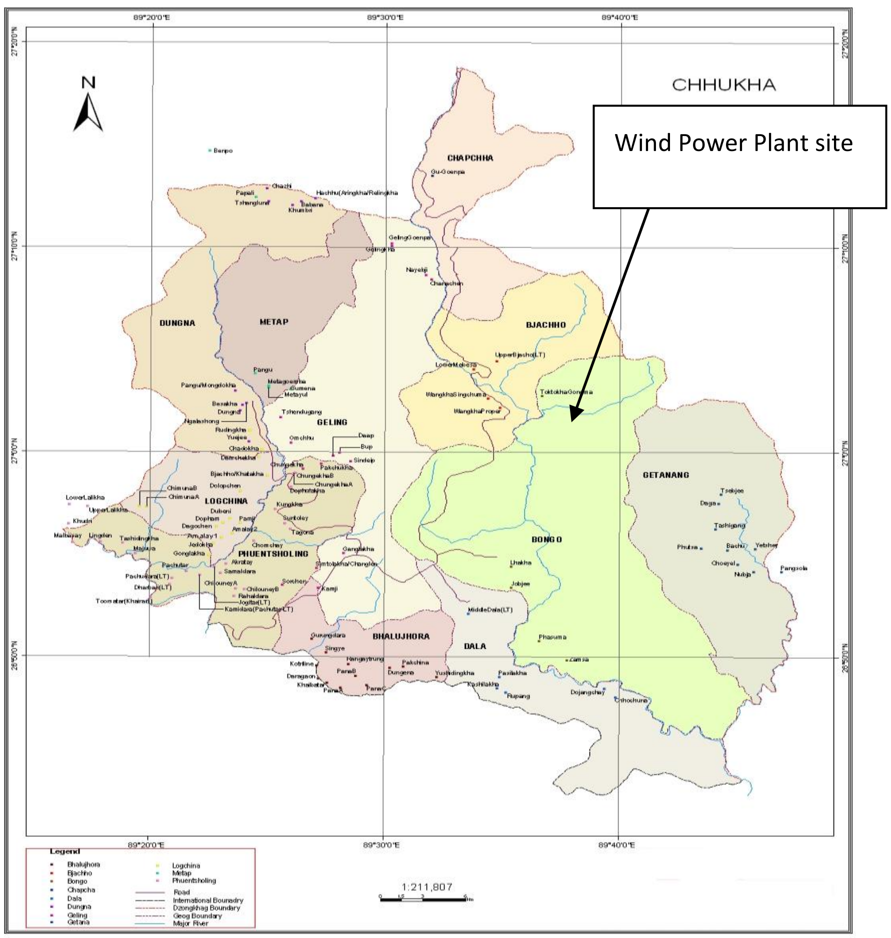
94. The objectives of the project are to pilot test wind power wind power generation, learn about the construction and operation of wind farms, and collect wind data to help determine the potential for producing wind power in the country. This will help alleviate power shortages in the winter (peak demand period). The proposed pilot project will support the RGOB's strategy to diversify energy resources, enhance long-term energy security, and generate

additional power to meet the growing peak demand in the winter.

4.3 Project Location

95. The wind power pilot project is planned at Tsimalakha village in Bijcho Gewog in Chukha dzongkhag. The latitude and longitude of the site are 27 degrees North and 89 degrees East, respectively. The distance from the dzongkhag administration office is about 4.5 km. Figure I-1 shows the site of the wind power pilot project in Chukha dzongkhag.

Figure I-1: Location of Wind Power Pilot Project Site in Chukha Dzongkhag



4.4 Details of the Wind Power Pilot Project

96. The proposed wind power pilot project consists of: 1) the construction and operation of two 180 kW pilot wind turbines at Tsimalakha site in Chukha dzongkhag and 2) the installation

of wind (measurement) masts at three additional sites. The key data of the pilot project at Tsimalakha site are shown in Table I-5.

Table I-5: Components of Wind Power Pilot Project		
S. No.	**Component**	**Quantity**
Element		
	Wind Turbine	
1	Unit capacity of wind turbine	180 kW
2	Number of wind turbines	2
3	Total generation capacity	360 kW
4	Hub height	31 meters
5	Turbine blade length	11 meters
6	Number of blades per turbine	2
7	Total land area required	
	(a) Permanent used (foundation)	81 m^2
	(b) Temporary uses (during construction)	300 m^2
Wind Mast		
1	Height	20 meters
2	Number of wind mast	1
Access Road		
1	Access road from existing road to site	800 m x 5 m
Grid Connection to 11 kV Line		
1	Connection line to power grid	163 m

97. The Tsimalakha site was selected for the proposed pilot wind power project following fieldwork that included visiting and assessing 16 known potential wind power sites in Bhutan. The Tsimalakha site was ranked first based on a number of criteria, including potential wind resources, land use, land ownerships, terrain, road access, transport constraints, distance to the power grid, distances to nearby houses, geological conditions for the foundation, and environmental and social sensitivity.

98. The DOE installed a wind mast at the Tsimalakha site in March 2010 to collect wind data for detailed analysis. For the feasibility study, wind measurement data at Tsirang site were used to develop a preliminary project design. The project design will be refined after the analysis of the actual wind data at the Tsimalakha site collected by the DOE for one year.

4.5 Costs of the Project

99. The cost estimates of the wind power pilot project ($US 2.15 million or Nu 96.75 million) are given in Table I-6.

Table I-6: Components of Wind Power Pilot Project

Item	US$
Wind Turbine	
2x180 kW wind turbines, tower, foundation, electrical connection, earthing, transport, freight, crane, commissioning, design, installation, project management, O&M training	1,345,000
Consulting Services	
Wind data analysis, energy output estimates	209,600
Design specifications, bid documents	
Bid evaluation, technical support, inspection	
O&M technical support	
Access Road to Wind Turbines	90,000
EMP and Social Mitigation Measures	25,000
Additional Wind Monitoring	75,000
3 wind masts ($43,000)	
Transport, installation, commissioning ($30,000)	
Total Base Costs	1,742,600
PIU Costs	81,000
Contingency	329,000
Total Costs	2,152,600

4.6 Implementing and Executing Agencies

100. The Department of Energy under the Ministry of Economic Affairs will be the Executing Agency (EA), and the BPC will be the Implementing Agency (IA).

5. DESCRIPTION OF THE ENVIRONMENT

5.1 Physical Resources

101. **Location.** Chukha dzongkhag, where the wind power pilot project is proposed to be installed, is located in southwestern part of Bhutan and shares its borders with the dzongkhags of Dagana to the east, Samtse and Haa to the west, Paro and Thimphu to the north, and the Indian State of West Bengal to the south. The total geographical area of Chukha dzongkhag is 1,882 square km. The total geographical area of the country is 38,394 square km.

102. The Chukha dzongkhag is administratively supported by a Dungkhag (Phuentsholing) and 11 Gewogs (Chapcha, Bjachho, Bongo, Getana, Geling, Dungna, Metakha, Lokchina, Daria, Sampheling and Phuentsholing). The wind power pilot project site falls in Bjachho Gewog. It is about 4.5 km from the dzongkhag administration office.

103. **Topography, Geology and Soil.** The elevation of Chukha dzongkhag varies from 200 m to 3,500 m above sea level. The elevation of the wind power pilot project site is 2,200 m above

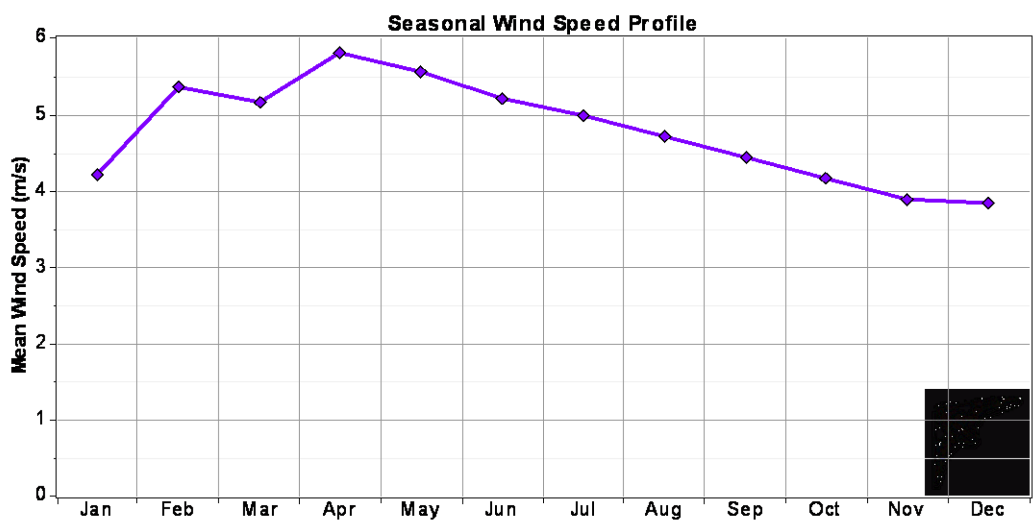
sea level. The topography of the project site is flat. The topography of Chukha dzongkhag as a whole extends to broad fertile valleys where agriculture and settlement are usually concentrated, especially near the Wong Chu River's banks.

104. The project site falls within the Lesser Himalayan formation. This includes a wide range of sedimentary and low-grade metamorphic rocks, including argillites and metargillites, sandstones and quartzites, limestone, dolomite and gypsum. Gneisses underlie in the entire dzongkhag, almost to the Indian border.

105. The soil in the project site is clayey loam. The soil color is blackish. No agriculture activity was seen near the project site. The soils near Wong Chu are sandy loam in texture and crops grow well as soil moisture is adequate. At the site, soils are shallow as there is stone grit underneath.

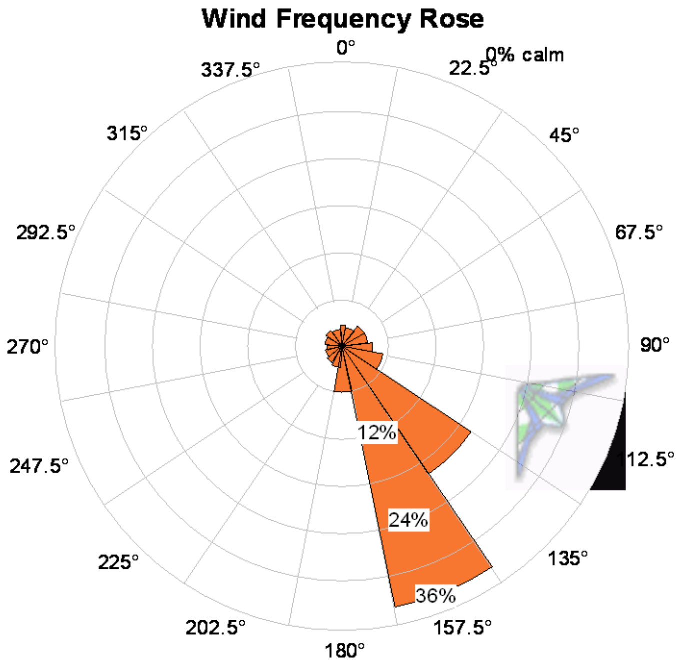
106. **Climate and Meteorology.** The climate at the project site and its surroundings is cool, with warm humid summers and chilly winters with snowfall. At the project site strong winds (>4 m/s) have been frequently observed. Figure I-2 shows the seasonal wind profile.

Figure I-2: Seasonal Wind Speed Profile



107. The dominant wind direction is from the southeast/south southeast to the north northwest/northwest. Figure I-3 shows a wind frequency rose diagram at the proposed site.

Figure I-3: Wind Frequency Rose Diagram Considered for the Project



108. The relative humidity in the project area ranges 63% to 90%, with an average of about 70%. The least humid period is during the pre monsoon (March-May). The average mean temperature for the warmest months of June and July is about 20° C to 30° C, while the mean temperature for the coldest months of January and February is about 10° C to 12° C. In January and December at the project site, there are occasional snowfalls and temperature goes below 0° C.

109. The average rainfall in the project area is around 1,000 mm, but sometimes the precipitation becomes much heavier. The precipitation is heaviest during the months of June to September.

110. **Air Quality.** Air pollution in Bhutan is a recent phenomenon that can be attributed to rapid urbanization. Diesel vehicles are the major source of urban air pollution. No information is available on the ambient air quality at Chukha or the project site because so far ambient air quality (PM, NO_x and CO) monitoring has been conducted only in Thimphu and Phuentsholing. The published ambient air quality data for these two cities were analyzed as the reference information for the project region. The project area has characteristics similar to Thimphu with respect to terrain and topography. The measured CO, NO_x, and PM_{10} concentrations in Thimphu are 7.14 mg/m^3, 10.49 ug/m^3 and 24.5 ug/m^3, respectively, which are well below the standards for these pollutants recommended by the World Health Organization. In the project area a better ambient air quality is expected because there are fewer pollution-generating construction and commercial activities and vehicular traffic. Hence, air quality is not a concern at the project site and surroundings.

111. **Surface Water.** The project area is drained by Wong Chu River. The Wong Chu joins Raidak River before going to the plains and to India through Phuentsholing. During the monsoons the heavy rains often cause flash floods in the valleys, which are very vulnerable to erosion. The construction of embankments in the erosion-prone areas and river diversion are being undertaken as protection measures. Surface water quality data for the project area are not available, but it is considered pristine as there are no pollution discharge sources in upstream of the project site.

112. **Groundwater.** There are no data available on the groundwater in the project site. Groundwater resources are also abundant with springs emerging from underground rocks, old landslides and fluvial deposits. Groundwater in landslide and alluvial deposits has been estimated at an exploitable rate of 3 liters per second per km^2. Currently water quality monitoring is conducted in the four major river systems of Bhutan only. No groundwater quality monitoring has been conducted in Bhutan. Generally the state of groundwater quality at the project site and its surroundings is expected to be good as no sources of groundwater pollution such as industrial effluents discharge have been noticed.

113. **Noise.** Noise is an important environmental attribute for the wind power project, as the wind turbines will generate noise. Data on measured noise levels are not available for the site and its surroundings because currently the NEC is measuring noise levels at Phuentsholing and Thimphu only. Major contributors to ambient noise are commercial and industrial activities and vehicular traffic. At the project site and its surroundings, noise is expected to be within the stipulated limits of the NEC for rural and residential areas (55 dB(A) during the day and 45 dB(A) at night). This is because there are few commercial activities and little traffic around the project site.

114. **Aquatic Environment.** Fish and other aquatic species in Wong Chu River include eight exotic species like the coldwater trout and other species introduced from warm water (downstream) such as grass carp (ctenopharyngodon idella), common carp (cyprinus carpio), silver carp (hypothalmicthys molitrix), catla (Catla catla), r-Rohu (labeo rohita), and mrigal (cirrhius mrigala). The other fish species reported in Wong Chu river are schizothorax progastus (asla), schizothorax moleworthii, acrossocheilus hexagonolepis, crossocheilus latius, tor putitora (mahseer), tor tor (mahseer), barilius barna, barilius bendelisis, puntius macropogon, puntius sophore, puntius ticto, puntius titus, barbus spp., labeo dero, garra annandalei, garra gotyla, danio aequipinnatus, danio dangila, brachydanio rerio, botia dario, rasbora daniconius, noemacheilous botia, batasio, mystus bleekeri, mystus vittatus, ompok pabda, channa striatus and mastacembelus armatus.

5.2 Ecological Resources

115. **Protected Areas.** There is no protected area in Chukha dzongkhag. The nearest protected area is Jigme Singye Wangchuk National Park (JSWNP), which is about 50 m from the

project site.

116. **Habitat and Flora in the Project Area and Surroundings.** The Chukha dzongkhag has 82.39 % of its geographical area under forests. The dominant type of forest in the project area and its surroundings is broad leaf forest. There is no forest at the project site.

117. The project site is not a known habitat to any endangered species of fauna. The project area and its surroundings have domesticated fauna.

118. Table I-7 contains a list of trees found in Chukha dzongkhag; it was provided by the dzongkhag Forest Office.

Table I-7: Trees in the Project Area and Surroundings

S. No.	Plants/Trees
1	Alnus nepalensis
2	Berberis arristata
3	Betula Spp
4	Boehmeria spp
5	Castopnis spp
6	Daphnephylum spp
7	Juglans regia
8	Larix griffithiana
9	Pinus wallichiana
10	Populus spp
11	Quercus griffithi
12	Quercus lanata
13	Querscus semecarpifolia
14	Rhus spp
15	Cupressus spp
16	Cryptomeria japonica
17	Acer cambelli
Source: Chukha dzongkhag Forest Office	

Biodiversity

119. **Species in Forest Areas of Chukha dzongkhag.** The most dominant forest type in the Dzongkha is broadleaf, representing about 60% of the total forest area. The second dominant category of forest is mixed conifer forest. The forests in the protected areas are mainly subtropical, warm broadleaved, and cool broadleaved forests. Trees commonly found in the subtropical zone – which extends 200 m up to 1,000 m – include bombax ceiba, ailanthus grandis, dillenia pentagyna, duabange grandiflora, schime wallichii, tetrameles nudiflora, mangifere sylvatica, terminalia myriocarpa, ostodes paniculata and species of musa, polyalthia, castanopsis, cinnamomum, fisus and grewia.

120. The warm broadleaved zone extends from the elevation of 1,000 m to 2,000 m and comprises species such as alnus nepalensis, macaranga spp. altinga excelsa, castanopsis indica, michelia excels, bombax spp., ficus spp., terminalia spp., acacaia, dalbergia, mussaendra roxburghii, rhaphidophora species, maesa spp., albizzia spp., dichroa febrifuga and engellhardia spicata.

120. The cool broadleaved forests occur from 2,000 m to 5,000 m and comprise mainly betula alnodes, elastotema spp., symplocus spp., lindera pulcherrima, persea spp., exbuckllandia populnea, cantanopsis hystrix, lithocarpus elegans, and eurya spp.

121. **Fauna and Avifauna in the Project Site and Surroundings.** The dzongkhag Forest Office provided the consultants with a list of fauna found in the project area and surroundings (Table I-8).

Table I-8: Animals and Birds in the Project Area and Surroundings

S. No.	Animals	Birds
1	Wild pig	Drongos
2	Sambar Deer	Shrikes
3	Barking Deer	Swifts
4	Asiatic black bear	Hoopoes
5	Common Leopard	Quailis
6	Yellow Throated Martin	Wood peckers
7	Langur	Barbets
8	Macaque	Fantails
9		Thrushes
10		Tits
11		Sparrows
12		Crow
13		Fly catchers
14		Finches
15		Babblers
Source: Chukha dzongkhag Forest Office		

122. None of the above mentioned faunal species are listed in the endangered list of the Forest and Nature Conservation Act. As per discussions with dzongkhag forest officers, migratory birds do not visit Chukha as a whole. The names of the protected wildlife species and birds mentioned in Schedule -1 A and Schedule -1 B of Forest and Nature Conservation Act are given in Table I-9.

Table I-9: Species Listed in the Forest and Nature Conservation Act

Common Name	Scientific Name
Schedule 1A – Protected Wildlife	

Table I-9: Species Listed in the Forest and Nature Conservation Act

Common Name	Scientific Name	
Asian Elephant	Elephus maximus	
Clouded Leopard	Neofelis nebulosa	
Golden Langur	Presbytis geei	
Musk Deer	Moschus Chrysogaster	
Pangolin	Manis crassicaudata	
Pigmy Hog	Sus sylvanicus	
Snow Leopard	Panthera unica	
Takin	Budorcas taxicolor	
Tiger	Panthera tigris	
Wild Buffalo	Bubalus bubalis	
Golden Masheer	Tor tor	
Spotted Deer	Axis axis	
Gaur	Bos gaurus	
Leopard	Panthera pardus	
Leopard Cat	Felis bengalensis	
Himalayan Black Bear	Selenarctos thibetanus	
Red Panda	Ailurus fulgens	
Serow	Capricirnis sumatraensis	
Protected Birds		
Black-Necked Crane	Grus nigricollis	
Monal Pheasant	Lophophorus impejenus	
Peacock Pheasant	Polyplectron bicalcaratum	
Raven	Corvus corax	
Rufous-Necked Hornbill	Aceros nepalensis	
Schedule – IB : Protected Plant Species		
Local Name	**Common Name**	**Botanical Name**
Agar/ agaru	Eagle Wood	Aquilaria malaccensis
Yartsa-guenboop	Chinese Caterpillar	Cordyceps sinensis
Pang-gen metog	-	Gentiana creassuloides
-	Snow Down Lily	Llyodia yummanesis
Tsher-ngeon	Blue Poppy	Meconopisis grandis
Kirang-shing	Yew	Taxus baccata
Bhreeng-geeradza Ginseng	-	Panax pseudo-ginseng

123. **Micro Fauna.** The project site and its surroundings have significant insect diversity. These include butterflies and moths (lepidotera), beetles (coleoptera), flies (dipteral), dragonflies and damselflies (odonate), true bugs (hemiptera), cockroaches (blattodea), grasshoppers and crickets (orthoptera), ants, bees, wasps (Hymenoptera), and spiders (arachnid). There are also frogs and toads (anura).

5.3 Economic Development Resources

124. **Land use, Industry and Agriculture.** Land use at the project site is industrial as the land belongs to the Bhutan Power Corporation (BPC). The land use of the proposed access road to the wind power pilot project is barren private land. The predominant land use of Chukha dzongkhag is forest (82.39%), followed by (9%), pastures (4%), and settlement (about 0.3%). The balance is in water bodies and rocky areas. Due to the flat terrain, fertile sedimentary soil layers, and suitable climatic conditions, most of the arable wetland in the dzongkhag is now under rice cultivation.

125. Major crops produced in Chukha dzongkhag include orange, potato, cardamom. Livestock rearing is a major occupation and provides opportunities for processing and trading in dairy products such as butter, cheese and milk because of availability of ready markets.

126. Chukha dzongkhag is endowed with tremendous economic opportunities as it has two special economic zones: Phuentsholing as a principal commercial center and Pasakha as an industrial estate. The presence of two mega hydropower projects in the dzongkhag is another significant positive point. These two mega hydropower projects are Chukha Hydro Power and Tala Hydro Power. As a result Chukha is the highest revenue generating dzongkhag in the country. The wind power pilot project site is around 5 km from the Chukha Hydro Power Project.

5.4 Administrative Infrastructure and Community Facilities

127. The dzongkhag administrative office at Chukha includes Offices of Revenue, Land, Forest, Planning, etc. Chukha town has amenities such as a bank, post office and communication centers.

128. The Chukha dzongkhag has 17 community primary schools, 4 primary schools, 7 lower secondary schools, 5 middle secondary schools, 3 higher secondary schools, and 33 non-formal education centers. The total number of students in these schools is 14,794. The literacy rate in the dzongkhag is 63.1%. The health facilities include hospitals, basic health units, and outreach clinics. Chukha dzongkhag has 3 hospitals, 9 basic health units and 28 outreach clinics. Chukha dzongkhag has 3 renewable resource research centers, 6 agriculture extension centers, 1 veterinary hospital, 6 livestock centers, and 2 forestry extension centers.

129. **Transportation.** There are good transportation facilities in Chukha dzongkhag. It has 233 km of national highway, 206 km of feeder roads, 28.4 km of farm roads, and 17 km of power tiller track. Tsimalakha village near the project site is connected by a 5.5 m wide bituminous road.

130. **Electricity and Communicaitons.** The households close to dzongkhag headquarters have

been electrified. Based on the information available from Chukha dzongkhag the number of households electrified is 10,323. The electrification percentage in rural households is around 70%.

131. In Chukha dzongkhag there are 3,979 fixed telephone lines, 368 rural communication facilities, 4 post offices and 15 bridges/suspension bridges.

132. **Water and Sanitation.** In Chukha Dzongkhag there are 199 water supply schemes. The percentage of households having rural water supply is 62%. In the dzongkhag the number of households having toilets/latrines is 5,832.

133. **Tourism.** At present, no important tourist sites exist in Chukha dzongkhag.

5.5 Social and Cultural Resources

134. **Demography.** The population of Bhutan includes many ethnic groups such as the Sharchops in the east, Ngalongs in the west, Khengpas in the central region, nomads in the north and Lhotshampas in the south. Because of the mix of ethnicities a wide variety of dialects are spoken, of which Dzongkha, Khengkha, Sharchop and various dialects of Nepali are the most common. Some of these ethnic groups can also be found in Chulkha dzongkhag.

135. The population of Chukha dzongkhag is 74,387. The dzongkhag has a sex (male to female) ratio of 1:1. In the dzongkhag about 68% of the population is rural residents while 32% are urban dwellers. The average number of family members per household is 4.56.

136. **History and Cultural.** Chukha dzongkhag was established in 1987, coinciding with the beginning of the sixth Five Year Plan. The dzongkhag has government owned, public as well as private, Lhakhangs.

137. In Bhutan traditions are followed religiously. Males and females wear their traditional dresses, the Kho and Kira. The same dresses are worn in Chukha dzongkhag too.

138. In Chukha dzongkhag there are no culturally significant structures. Most of the larger villages have a temple, and there are smaller Buddhist shrines both inside and outside inhabited areas. There are other places or objects that are of significance to the community, including particular trees, river and other locations.

6. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATING MEASURES

139. This section summarizes the anticipated environmental impacts and mitigation measures for the proposed wind power pilot project. Using the Rapid Environmental

Assessment (REA) checklist, this pilot project has been classified as Safeguard Category B for environment and involuntary resettlement.

6.1 Environmentally Insignificant Issues

140. Although the Chukha dzongkhag in which the wind power pilot project is proposed to be located has forest areas and wildlife, no impact is expected as the project site is far from the forested areas. The project site is subject to human interference as it is the possession of the BPC.

141. Based on the REA checklist following impacts are considered as insignificant:

- Physical Resources: Geology, climate and meteorology, and groundwater resources and quality
- Ecological Resources: Protected areas, forests
- Economic Development Resources: Tourism, industry and agriculture
- Social and Cultural Resources: History and culture.

6.2 Environmentally Significant Issues /Valued Environmental Component

142. Based on the REA checklist, the experience of the consultants, field visits and discussions with various government officials, the following issues were identified as valued environmental components:

- Physical Resources: Topography and soil, air quality, groundwater quality and sources during excavation, surface water resources and quality, noise levels, and aquatic environment
- Ecological Resources: Biodiversity
- Economic Development Resources: Community facilities, transportation, electricity and communication, water and sanitation and demography
- Social and Cultural Resources: Demography.

143. Since the impacts are associated with different phases of the project, these components are discussed and mitigation measures are proposed for each phase of the project in the following subsections.

6.3 Topography and Soil

Impacts

144. **Construction Phase.** During construction, visible changes in the topography of the project site will result from laying the wind turbines' foundations, erecting the substation, establishing the construction site office, building access road, and providing connections to the 11 kV distribution line. The wind mast has already been installed.

145. The impacts on the area's soil will be felt due to accidental spillage of fuel, lubricants and paints during construction and construction wastes in the project site and its surroundings if they are not disposed properly.

146. **Operations Phase.** The impacts on topography will be visible due to the access road, overhead electric lines for grid connection, wind turbines and electric substation. These changes in topography will last until the end of the project life.

147. During the operation phase no impacts on soil are anticipated as there will be no generation of solid waste or liquid effluents from the operation of the wind power pilot project.

Mitigation Measures

148. **Construction Phase.** The topographical changes due to the construction and erection of the project components will not be visually displeasing. The construction duration will be for a maximum period of four months. The wind turbines are of low capacity and the movement of turbine blades will not be rapid.

149. In order to avoid impacts on soil the paints, lubricants, fuel oil, and other materials used in construction will be stored in tightly closed containers and these will be handled with utmost care. The contractor will create proper sanitation facilities at the construction camp in the form of septic tanks or soak pits. The construction wastes will be utilized to the extent possible in the fill works of access road. The non-usable wastes will be disposed off at site as they are identified by the PIU.

150. **Operations Phase.** In consultation with the dzongkhag's Forest Department, shrubs and low height trees will be planted near the boundary of the project site and on the side slopes of the access road to improve the look of the project site.

151. Since no impacts on soil have been identified during the operations phase, no mitigation measures are warranted.

6.4 Ambient Air Quality

Impacts

152. **Construction Phase.** During the construction phase impacts on ambient air quality will result from construction dusts, exhaust fumes of construction vehicles and machinery, and earth works at access road and project sites. The foundation works for the project site will last for 2-3 days and an additional 2 to 3 weeks for curing the concrete. Since the nearest habitation to project site, Tsimalakha village, is at least 800 m from the project site, impacts on ambient air quality at the village are not anticipated.

153. **Operations Phase.** Impacts on ambient air quality will result from the occasional use of vehicles for maintaining and repairing the wind turbines.

Mitigation Measures

154. **Construction Phase.** The PIU will ensure that all vehicles and machinery used in construction are properly maintained and have pollution control certificates. To control dust emissions at the site and access road, the contractor will make spray water at least twice a day, i.e., in the morning and afternoon.

155. **Operations Phase.** During this phase there will be occasional movement of vehicles for inspection, scheduled maintenance and emergency repair. Vehicles with pollution control certificates will be used. This will ensure there is no adverse impact on ambient air quality.

6.5 Ground and Surface Water

Impacts

156. **Construction Phase.** During this phase impacts on surface water quality and resources will be felt due to the consumption of water for construction activities. This consumption is not to exceed 50 m^3/day for all construction activities. Impacts on water quality may result if construction wastes are improperly disposed and washed into surface water bodies after storms. The impacts will also be felt due to erosion of the road embankment during the monsoon season if the access road does not have adequate cross-drainage structures and proper compaction of side slopes.

157. Impacts on groundwater may also be felt due to excavation for turbine foundations and the access road, if they are present at the project site and alignment of the access road. If there are no groundwater resources in the project area and its surrounding, there will be no impact on groundwater resources and quality.

158. **Operations Phase.** During this phase there will be a requirement of water for the green belt in the initial two years during non-monsoon months, but there will be no requirement for water to operate the wind power pilot project. There will be no generation of any liquid effluents during the operation phase, either. Impacts will be felt if a proper run-off drainage system is not provided for the access road and the project site. During the operation phase no impacts on groundwater quality and availability are anticipated.

Mitigation Measures

159. **Construction Phase.** In order to minimize the impacts, adequate cross-drainage structures will be included in the access road's design. The access road, which will be close to the toe of a hill, will have significant runoff during monsoons. There are two minor natural streams flowing from uphill of the proposed alignment of the access road. There will be adequate size culverts for these streams. Temporary drainage arrangements will be provided at the site so that storm water does not wash away the construction materials. All construction works will be carried out during non-monsoon months. Proper drainage arrangements will be included in the project site design. The water for the construction work will be drawn from the nearest surface water source or from the supply source of the dzongkhag administration, with due permission. The embankment and side slopes of the access road will be properly compacted.

160. **Operations Phase.** The project operator will arrange water for the irrigation of the green belt during non-monsoon months in the initial two years or before the trees mature. No erosion impacts at the access road are anticipated because side slopes will be properly stabilized first and after the first monsoon there will be natural vegetation on the slopes to prevent erosion. A proper drainage system will be included in the wind power pilot project site design.

6.6 Ambient Noise

Impacts

162. **Construction Phase.** During construction noise will be generated from vehicles and machinery at the construction site. The nearest house to the project site is about 250 m away and the nearest village is about 800 m. Construction noise will be intermittent and construction will not last longer than four months. Due to the distance, the construction noise may not be felt at Tsimalakha village or the nearest house.

163. **Operations Phase.** Here, noise will be generated from occasional vehicle movement and machinery operation for maintenance and repair purposes. The noise will not be heard beyond 200 m from the project site. Because there is no household within 200 m, no impacts are anticipated due to vehicle movement for repair and maintenance.

164. At a distance of 200 m or more from the project site, the noise generated from the proposed wind turbines will be within the national ambient noise standards (55 dB(A) during the day and 45 dB(A) at night) set by the NEC. Based on the noise information provided by the turbine manufacture, there will be no noise impact on the nearest household. The noise levels generated from the two 180 kW turbines are estimated to be 45 dB(A) at 190 m distance, 40 dB(A) at 330 m, and 35 dB(A) at 554 m.

Mitigation Measures

165. **Construction Phase.** Construction noise will be mitigated by restricting construction activities to the daytime, and construction dusts and wastes by following good practices for handling and disposing construction materials including regular water sprays, slow truck speeds on dirty roads, etc.

166. **Operations Phase.** The turbine noise levels at the nearest house are unlikely to exceed the prescribed standards. As a precautionary measure, the actual noise level at the nearest house will be measured for 7 consecutive days to cover the entire range of wind speeds prevailing at the site. If the actual noise levels exceed the national ambient noise standards, mitigation measures in the form of constructing noise barriers on three sides (north, south and west) of the nearest house will be implemented. In addition, trees will be planted along the eastern boundary of the project site (towards the nearest house) to attenuate the noise and provide good aesthetic look to the project site. A budget has been built into the Environmental Management Plan (EMP) for these mitigation measures.

6.7 Aquatic Environment

Impacts

167. **Construction Phase.** The impact on aquatic environment will result from the disposal of liquid effluents, solid wastes or construction wastes in the water body. There is no perennial water body having aquatic life in the project area. The Wong Chu River is at about 3.0 km from the plant site. The chances of construction wastes reaching to Wong Chu are very remote; hence, no impact is envisaged on aquatic life during the construction phase.

168. **Operations Phase.** There will be no generation of liquid effluents and solid phase from the wind power pilot project. Hence, no impact on aquatic environment is anticipated.

Mitigation Measures

169. **Construction Phase.** During the construction phase no impacts have been identified; therefore, no mitigation measures are warranted.

170. **Operations Phase.** During the operation phase no impacts have been identified;

therefore, no mitigation measures are warranted.

6.8 Habitat and Forest

Impacts

171. **Construction Phase.** There is no forest at the project site of its immediate vicinity. Neither is the project site a habitat area for wildlife. No tree cutting is involved for the proposed pilot project, access road, or connection to the power grid. However, vegetation will be removed for the construction of the facilities.

172. **Operations Phase.** In this phase there will be no impact on forests as the project site is not in a forest area. The impacts of noise evaluated indicate that beyond 200 m noise levels will be within the national ambient noise standards for rural/residential areas. There is no habitat for wildlife within 200 m; therefore, no impacts are anticipated.

Mitigation Measures

173. **Construction Phase.** No impacts have been identified during the construction phase on habitat and forest; therefore, no mitigation measures are warranted.

174. **Operations Phase.** No impacts have been identified during this phase on habitat and forest; therefore, no mitigation measures are warranted.

6.9 Biodiversity

Impacts

175. **Construction Phase.** No impact on flora is anticipated during the construction phase because there are no requirements to cut trees for the pilot project.

176. Since there is no river or lake within a distance of 3 km, the project area does not attract avifauna (birds) and fauna. There is no evidence of any endangered species of flora and fauna in the project area and surroundings; therefore, no impact on biodiversity is anticipated.

177. **Operations Phase.** In the operation phase a positive impact on biodiversity is anticipated because trees will be planted along the eastern boundary of the project site to attenuate the noise and shrubs will be planted on the side slopes of the access road.

178. There may be accidental bird hits on turbine blades. The chances of these hits will be

rare as birds will be distracted due to the turbine noise. There are no known migration paths of birds in Chukha dzongkhag.

179. Since no impacts have been identified during the construction and operation phases, no mitigation measures are warranted.

6.10 Land Use and Involuntary Resettlement

Impacts

180. **Construction Phase.** The BPC, as the IA, has agreed to give the land for the development of the wind power pilot project. Thus, there will be no impact on land use at the project site. However, there will be an impact on the approximately 4,400 m^2 of land proposed to be acquired for the access road. There will be no change in the use of land through which the overhead connection line to the 11 kV distribution line is planned.

181. **Operations Phase.** In the operation phase there will be no further changes in land use as all changes will have been completed before the start of construction.

Mitigation Measures

182. **Construction Phase.** The dzongkhag administration will acquire land for the access road. Four land owners have agreed to provide a portion of their land for construction of the access road to the project site and one land owner has agreed to provide the right of way for the grid connection line. The government will provide substitute land in accordance with the Bhutan Land Act and ADB's *Safeguard Policy Statement 2009.*

183. **Operations Phase.** Since no impacts have been identified in the operation phase on land use, no mitigation measures are warranted.

6.11 Common Property Resources and Utilities

Impacts

184. **Construction Phase.** During the construction phase there will be no impact on common property resources such as schools, hospitals, BHUs or ORCs, water supply sources, telephone lines and poles, as none of these are present at the wind power project site or the access road land. No impact on a BPC 66 kV transmission line near the project site is anticipated.

185. No religious structure such as chortein, lakhang and temple will be affected during the construction phase, as none of these is present at the project site and on the access road.

186. **Operations Phase.** There will be no impact on common property resources, utilities and religious places during the operations phase.

Mitigation Measures

187. **Construction Phase.** Construction activities will be restricted within the project site to avoid any impact on the nearby 66 kV transmission line. The connection line to the 11 kV distribution line will be an underground cable within the project site boundary and overhead wire from the site boundary to the 11 kV line to avoid inference to the 11 kV and 66 kV power lines.

188. **Operations Phase.** No impacts have been identified on common property resources and utilities; therefore, no mitigation measures are warranted.

6.12 Traffic and Transport

Impacts

189. **Construction Phase.** During this phase, the trucks carrying construction materials, wind turbines and other equipment will travel on the Thimphu-Phuentsholing highway and the access road to the project site. The length of turbine blades is 11 m; therefore, there will be disruptions to local traffic on the national highway to Tsimalakha. The turbines will be transported to the site after the construction of the access road is complete. The transportation of construction materials may inconvenience local traffic.

190. **Operations Phase.** There will be movement of vehicles and machinery on the road connecting Tsimalakha with the National Highway for scheduled maintenance and emergency repair. This movement will be occasional. No significant adverse impacts are anticipated.

Mitigation Measures

191. **Construction Phase.** To minimize inconvenience caused by vehicle and machinery movement during the construction phase, a construction traffic schedule will be prepared in consultation with the dzongkhag administration. The construction traffic will last only three to four months. There will be no construction traffic at night on the road connecting Tsimalakha village to the National Highway to avoid excessive noise. For the transport of wind turbines from Phuentsholing to the project site through the National Highway, the PIU will consult with the dzongkhag administration and Department of Roads to ensure the least disruption to traffic on the National Highway.

192. **Operations Phase.** During the operations phase no significant adverse impacts have been identified; therefore, no mitigation measures are warranted.

6.13 Aviation Hazards

193. No aviation hazards will be created by the project as the project site is not in any flight paths. Furthermore, the wind mast height is 20 m only; this height will not cause any aviation hazards.

6.14 Human Health

Impacts

194. **Construction Phase.** During the construction phase no adverse impacts on health are anticipated as the nearest village is over 0.8 km away and the nearest house at about 250 m away.

195. **Operations Phase.** No negative impacts are anticipated noise is not expected beyond 200 m from the project site and within 200 m there is no habitation or household. The distance of the nearest household is 250 m.

Mitigation Measures

196. **Construction Phase.** Since no adverse impacts have been identified, no mitigation measures are warranted.

197. **Operation Phase.** Since no adverse impacts have been identified, no mitigation measures are warranted.

6.15 Positive Social and Environmental Benefits

198. Wind energy is a clean, sustainable and renewable form of energy. The project will have a host of environmental and social benefits, including:

- Use of clean and sustainable wind energy
- Creation of employment opportunities for road and site survey, construction, and operation of the project
- Increased industrial and economic activities from reduced load shedding
- No loss of energy in transmission as the power generated is fed into the grid at the project site.

6.16 Safety Features in the Wind Power Pilot Project

199. The wind power pilot project will have safety features to minimize damages to its components during natural disasters such as earthquakes and severe wind storms. The turbine foundations will be earthquake resistant. The turbine blades will stop moving automatically at a wind speed exceeding 25 m/s.

6.17 Conclusion

200. Based on the above assessment, negative impacts of the wind power pilot project are limited. These can be mitigated to an acceptable level with the mitigation measures proposed.

7. ANALYSIS OF ALTERNATIVES

201. Three alternatives were considered for the wind power pilot project. These were the 1) No Project Scenario (no implementation of project), 2) Project Scenario, and 3) Use of other forms of energy scenario (such as coal or biomass). These alternatives are summarized below.

7.1 No Project Scenario

202. Currently Bhutan is dependent solely on the run-of-river hydropower plants that have drastically reduced generation capacity in the winter dry season. Thus, the country faces power shortage problems in the winter. The power shortage problems will continue to worsen under the No Project Scenario. Furthermore, the nation's power security will not be improved as it will continue to relying exclusively on hydropower, which may be affected by global warming.

7.2 Project Scenario

203. This scenario will provide a clean and sustainable form of energy. The project will help diversify energy resources, enhance the nation's long-term energy security, and alleviate winter power shortage problems. In addition, the pilot project will enable the DOE and the BPC to gain actual experience in the planning, construction and operation of wind farms so the nation's wind resources can be explored more cost-effectively.

7.3 Other Forms of Energy Scenario

204. The other forms of possible energy resources in the country may include solar, biomass and coal. In the current project, solar energy is being planned to be used for the off-grid rural

electrification of remote isolated villages where on-grid extension is not feasible. The biomass- and coal-fired power plants are a possibility, but these power plants will result in substantial air quality degradation. In addition, the transportation of coal and biomass in Bhutan will be difficult and expensive due to the difficult terrain and lack of suitable highways.

7.4 Comparison of Alternatives

205. All three alternatives considered are compared in Table I-10.

Table I-10: Comparison of Alternatives

Parameters	No Project Scenario	Project Scenario	Other Forms of Energy Scenario (coal- or biomass-fired power plants)
Economic cost	No project scenario will be cheaper as there will be no investment cost for wind power Load shedding in the winter will continue	The project scenario will require investment and the economic cost may be higher No impact on the country's balance account as the pilot project is funded by an ADB grant	High cost and may not be feasible to install due to terrain and techno-economic reasons There will be high coal import cost as there is little coal reserve in the country.
Developmental impacts & people's perceptions	Economic development in the country will be slow because of load shedding	Load shedding will be reduced, resulting in increased economic development of country	Coal- and biomass-based power plants are not feasible. Thus, load shedding will continue resulting in slow economic development
Social benefits	Less employment opportunities due to the curtailment of industrial development resulting from power shortages in the winter	Clean and renewable energy This will help in the electrification of rural households to achieve the government's target of Electricity for All by 2013 The social benefits will be better quality of life for the electrified rural poor	No social benefits as collection of biomass from forests will worsen deforestation in the country

Table I-10: Comparison of Alternatives			
Parameters	**No Project Scenario**	**Project Scenario**	**Other Forms of Energy Scenario (coal- or biomass-fired power plants)**
Environmental impacts	Will have not incremental benefits as the Project Scenario does not generate any environmental losses such as tree cutting, air pollution or water pollution	No environmental impacts as noise levels are likely to be within the national standards beyond 200 m from the project site	Coal- and biomass-fired power plants l will result into huge air pollution and solid waste problems
Health	No impact on health	Noise impact unlikely, planned mitigating measures will be implemented if the actual noise levels exceed the national standard	Adverse impacts on health due to high levels of air pollution from coal- or biomass-fired power plants

7.5 Conclusion

206. Based on the above analysis, the Project Scenario will be the best option for the nation. The project will generate clean renewable wind power to alleviate the winter power shortage problems and support the government's objective of providing electricity for all by 2013.

8. INFORMATION DISCLOSURE AND CONSULTATIONS

207. The successful implementation of the project requires coordinated efforts of all stakeholders at different levels. Hence, consultations were carried out to inform and educate stakeholders about the proposed project, and seek their inputs for improving the project design and implementation. The consultations for the proposed project were important as there was a requirement of land acquisition for the access road to the project site.

208. The consultations held were useful in identification of the issues associated with the project as well as the needs of the population likely to be affected by the project. This participatory process helped convince the public to support the project and minimize the potential impacts. The involvement of the various stakeholders ensured that the targeted population and other stakeholders are informed and consulted, and are allowed to participate at various stages of project development.

8.1 Objectives

209. The main objectives of the consultations were to inform the stake holders, seek their inputs, and maximize the benefits of the project. Other objectives of the consultations included:

- To promote public awareness about the wind power pilot project;
- To educate the communities/individuals about benefits of the project;
- To solicit the views of communities/individuals residing close to the project and/or being affected by the project ;
- To gather inputs from the targeted population/project affected persons for improvement in the project configuration and implementation;
- To stimulate community self evaluation and analysis; and
- To ensure lessening of public resistance by providing them a platform in the decision making process.

8.2 Methodology Adopted for Public Consultations

210. **Stages and Levels of Consultation.** The consultations were conducted right from the start of the PPTA to refine the scope of the project. This project inception workshop was organised by the PPTA Consultants on December 3, 2009.

211. Public consultations have been held at three levels as follows:

- Local level: Consultations at Tsimalakha village with project affected persons and general public
- Dzongkhag level: Consultations involving Dzongdag, local BPC officers, local Forest Department officers, dzongkhag environmental officer, land record officers ; and
- Institutional level: Consultations with the National Environment Commission (NEC), Bhutan Power Corporation Ltd., Department of Energy, the Ministry of Finance, JICA, ADB, etc.

212. During visits to Chukha formal discussions were held with Dzongdag and informal discussions with locals, Gup (village head) and project affected persons. A checklist of questions was kept ready and responses were elicited from people.

213. **Institutional Level / Stakeholders Consultation Workshop (Inception Workshop).** The institutional level consultations were held with representatives of institutions having stakes in the project. These included the NEC, the BPC, the Department of Energy (DOE), and the MOF.

214. All institutional stakeholders were invited to the December 3, 2009 inception workshop to comment and suggest regarding the proposed project.

215. **Contents.** The consultations with institutional officials focused on the following issues:

- Project description: - Need for renewable form of energy including wind, biogas, and solar
- Advantages and low level of pollution (emissions/effluents/solid wastes)
- The extent and nature of social and environmental impacts
- People's participation in planning, implementation and monitoring & evaluation of the project.

216. **Summary.** The consultations at Tsimalakha village and dzongkhag level were held on December 16, 2009 and March 26, 2010. These are summarized below. The list of participants is available upon request.

8.3 Public Consultations Held

With Dzongkhag Administration

217. The environmental and social experts of the PPTA Consultants team and Mr. Nar Bahadur, Assistant Executive Engineer of the RED met with Chukha Dzongdag and officers. Prior to the consultation, a letter was sent to Dzongdag from the RED about purposes of consultations. The Dzongdag welcomed the project and assured that all help will be provided to the RED and consultants so that project is implemented in his dzongkhag. The Dzongdag and environmental officer stated that at Tsimalakha no migratory birds are coming because the site is away from Wong Chu River and the elevation is too high. The nearest protected area from Tsimalakha is JSWNP at about 50 km from the project site. The Dzongdag indicated that dzongkhag administration can acquire the land for the project and land owners will be provided compensation as per the RGOB laws and in case they want substitute land that can also be provided by the dzongkhag administration as land is available at other locations.

Public Consultation at Project Site near Tsimalakha Chiwog (Village) on December 16, 2009 and March 26, 2010

218. There were 3 participants in the December consultation and 8 participants in the March consultation. The participants included project affected persons (PAPs) of the proposed access road, owner of the nearest house to the wind power project site, and owner of the plot through which overhead line from the project site to the power grid will pass to connect to the 11 kV grid. All participants welcomed the project and they were happy that the existing road to Tsimalakha will be improved and an access road will be constructed from Tsimalakha village to the project site. These improvements will increase the land value of the area. The owner of the nearest house to the project site said that he has no objection for the installation of the wind power project at the site. He suggested that plantation in general should be taken up at the project site and locally grown trees should be planted. The land owners of the proposed access

road stated that they have no objection to the proposed access road and will accept compensation or substitute land whatever is offered by the government. The Consultants informed the participants that due to operation of wind turbines there will be generation of noise and in night time slightly higher noise levels may be felt within 200 m distance. The participants said that they have no objection to that as during night wind also makes a lot of noise. The consultants informed that after installation of the project noise levels will be measured at various distances during day and night for 7 consecutive days and if noise levels at the nearest house exceed the national ambient noise standards mitigation measures in the form of noise barriers on three sides of the house and plantation on the eastern direction along the boundary of the project site will be provided to bring down the noise levels within the acceptable limits. The house owner and participants welcomed and accepted these mitigation measures. The participants also suggested that proper arrangements of drainage at the access road and the project site be made as in monsoon months there is huge run off from hill on eastern side of the project site. The consultants replied that design and layout of the project site and access road will reflect this suggestion. The land record officer informed that there are 4 land owners will be affected by the proposed access road and a single land owner affected by the proposed 163 m grid connection line. The land owner of this land has no objection to providing the right of way for the overhead grid connection line.

219. The consultants informed that during construction there will be temporary dusts generated from construction vehicles, and machinery at the construction site. One of the participants suggested that water spray should be carried out and construction activity and transportation of construction materials should not be carried out at night.

8.4 Responses to Public Concerns in the Project Design

220. The project design has taken into consideration of the inputs from the public consultations. A summary of the issues raised and responses is given in Table I-11.

Table I-11: Summary of Responses to the Issues or Concerns Raised in Public Consultations

Issue/Concern Raised	Responses/Comments Provided
Locally grown trees should be planted at the project site and on the side slopes of access road	Locally grown trees, in consultation with the Forest Department, will be planted on the eastern boundary of the project site to reduce noise levels at the nearest house
There is frequent storm run-off during the monsoon and proper drainage arrangements at the project site and at access road should be established	Adequate cross-drainage structures in the access road and proper drainage arrangements at the project site will be provided.
Water spraying should be carried out to suppress construction dust, and	The consultants and DOE gave assurances that the necessary conditions will be put in the contract so that there is no construction activity or transportation of construction materials

Table I-11: Summary of Responses to the Issues or Concerns Raised in Public Consultations	
Issue/Concern Raised	**Responses/Comments Provided**
construction activity should not be carried out at night	at night. Measures to mitigate construction impacts will also be included in the EMP.

8.5 Conclusion

221. Based on the above analyses, all concerns of the public and project affected persons have been taken into account in the project design. The suggestions of institutional stakeholders have also been considered through inception workshop and meetings, and through circulation of deliverables of the consultants to all concerned departments of the RGOB for review and comment.

9. GRIEVANCE REDRESS MECHANISM

222. No major environmental issues have been identified for the wind power pilot project. Hence, no complaints related to the environment are anticipated. But to address any unforeseen environmental issues during construction and operation, a grievance redress mechanism was formulated to resolve them. During the construction phase a complaint register will be available at the construction site and will be made accessible to public. Any complaint received will be resolved within seven days by the operator who BPC appoints to operate and maintain the wind power pilot project.

223. In the event the operator is not able to resolve the complaint, the PIU manager will provide backup support to resolve it. The Environmental Management Plan implementation will be part of the terms of reference of the operator, and the Plan's costs will be part of the project's operations cost. The BPC will adopt an open door policy to receive any suggestions for better management and operation of the project.

10. INSTITUTIONAL REQUIREMENTS, ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

10.1 Institutional Requirements

224. The wind power pilot project will be implemented and monitored by the BPC, which is the Implementing Agency (IA).

225. The Department of Energy of the Ministry of Economic Affairs (MOEA) will be the Executing Agency (EA). The PIU manager will be responsible for implementing the EMP. The BPC will also appoint an operator under the PIU to be responsible for the operation

and maintenance of the wind power pilot project.

226. The BPC will be responsible for ensuring that the project complies with the environmental requirements of the ADB as well as the National Environment Commission (NEC). The PIU manager will be responsible for meeting all project reporting requirements.

227. The EMP will be a part of training program to be given to the operators by an international consultant.

228. All the statutory clearances (at the national, dzongkhag and local levels) for implementing the wind power pilot project have been obtained by the DOE in compliance with the national/dzongkhag laws and regulations and in accordance with ADB's environmental policy and guidelines.

10.2 Environment Monitoring Plan

229. To ensure the effective implementation of mitigation measures and the EMP during the construction and operations phases of the wind power pilot project, an Environmental Monitoring Plan will be implemented (Table I-12).

230. The BPC will have a full-time PIU manager who will also monitor the EMP's compliance during these phases of the project.

10.3 Environmental Management Plan

231. The EMP includes specific mitigating measures for the negative impacts identified. The EMP includes the location, timeframe, implementation and oversight/supervisory responsibilities for each measure.

232. The identified impacts and suggested mitigation measures, with institutional responsibilities, are summarized in Table I-13.

10.4 Environmental Management Plan Cost

233. Based on the EMP described above, cost estimates are included for the specified mitigating measures. These include: 1) green belt development, 2) shrub planting, 3) tree planting at the nearest house, and 4) procurement of an integrated noise measurement meter. The integrated noise measurement meter is recommended because no rental noise monitoring meters are available in Bhutan. There will be frequent requirements for noise level measurements (during construction, during operation before the implementation of noise

mitigation measures, after their implementation, and on receipt of any public complaints). Table I-14 presents the EMP budget.

11. FINDINGS, RECOMMENDATIONS AND CONCLUSION

11.1 Findings

234. The findings of the IEE are:

- The wind power pilot project will help diversify the nation's energy resources, enhance energy security, and reduce the shortfall of power in winter months.

- The construction impacts will be temporary and limited to the construction period, which is not to exceed four months. The noise levels will be within the stipulated limits beyond a distance of 200 m.

- The potential environmental impact during operation is noise generation. The nearest house to the project site is about 250 m away. The noise levels from the wind turbines at this distance are expected to be within the national ambient noise standards set by the NEC. At Tsimalakha village, which is located over 0.8 km from the project site, no noise impact from the project is anticipated.

11.2 Recommendations

235. A green belt development at the eastern boundary of the project site is recommended to attenuate noise levels at the nearest house (250 m to the northeast).

236. Ambient noise level measurements will be carried out at Tsimalakha village and the nearest house during the operations phase. In case these are found to exceed the national standards, mitigations in the form of noise barriers on three sides of the nearest house and green development on the eastern side of the project site will be implemented. After implementation of the noise mitigation measures, noise monitoring will be carried out to ensure the ambient noise levels are below the national standards.

237. The PIU manager will ensure that no construction work or transportation of construction materials is carried out during the night.

Table I-12: Environmental Monitoring Plan						
Environmental Component	**Project Stage**	**Parameter**	**Location**	**Duration / Frequency**	**Implementation**	**Supervision**
A: Construction Stage						
Ambient air quality in the project vicinity and access road construction	Construction	Dust suppression through water sprays	Access road, project site and grid connection rights of way for a 163 m long road Construction material storages piles	Twice a day (once in the morning, and once in the afternoon)	Construction Manager at site	PIU manager
Noise levels	Construction	Noise generation from construction activities, noise level measurements using portable digital noise meter	Tsimalakha village, the nearest house to the project site	Once during construction	Construction Manager at site	PIU manager
Temporary drainage arrangements at site, and access road	Construction	Visual observation for temporary drainage arrangement at site and access road under construction	Site and access road	Before start of monsoon	Construction Manager at site	PIU manager
B: Operation Stage						
Noise levels	Operation	Noise levels during the day and night according to the NEC's standards	Tsimalakha Village, the nearest house to the project site	Continuously for seven days	Operator of the project	PIU manager
Survival of shrubs at the project site and side slopes of the access road	Operation	Ensure minimum survival of 80% of planted trees and shrubs	Project site, side slopes of the access road	Once a year before onset of monsoon	Operator of the project	PIU manager

Table I-13: Environmental Management Plan (EMP)

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
A. Pre-Construction and Construction Phase						
Contamination of soil due to camp establishment, construction waste disposal and accidental spillages of fuels, lubricants, paints, improper construction vehicle/machinery maintenance, etc.	Provide proper sanitation facilities such as septic tank and soak pits at construction camps Use all construction wastes in embankment filling of access road to the extent possible; the wastes that cannot be used will be disposed of at sites approved by PIU Handle all liquid materials such as paints, fuels and lubricants with utmost care and store in containers. All construction vehicles/ machinery maintenance will be done at the workshop. All refueling will be done with the utmost care.	Spillage of fuels, lubricants, paints Handling of construction wastes Vehicle/ machinery maintenance and refueling	Visual observations daily	Contractor(s)	PIU manager	Incidental to work
Ambient air quality	All construction vehicles and machinery to conform to the emission standards and will have pollution control certificates There will be regular water sprays at least twice a day at the construction site of the access road, and project site	Dust generation due to construction activities and transport of construction materials	Every day during the construction phase	Contractor(s)	PIU manager	Incidental to work

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
	All construction materials will be stored in a shed as possible to reduce chances of the suspension of dust due to wind Covered vehicles/trucks will be used to avoid material spillage during transport					
Surface water quality and consumption	No construction waste materials will be disposed of in any surface water bodies Contractor will obtain a permission from dzongkhag administration to take water for construction purposes from river/government water supply Temporary drainage arrangements will be provided for storm water runoff at the project site and access road during construction; adequate cross drainage structures will be included in the access road design for storm water run off Construction materials will be properly stored to avoid being	Specific temporary drainage arrangements at site, permission from dzongkhag administration for water use, soil erosion measures on side slopes of the access road	During entire construction phase	Contractor(s)	PIU manager	Included in project implementati on cost

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
	washed away by storm water flow Provide temporary protection measures for soil erosion at side slopes of the access road and avoid works during monsoon					
Ambient noise levels	All construction equipment and machinery will be fitted with exhaust silencers All equipment and machinery to be used in construction will have acoustic enclosures and comply with the local prescribed noise levels Blasting if required will be carried out during the day time only. The blasting will not be continuous. Locals will be given notice about blasting. All local laws will be complied with during blasting. Blasting will not be carried out during night time All practical measures including portable noise barriers will be taken to control the noise generated due to construction activities.	Noise levels due to all construction activities and transportation of construction materials	Every day during construction	Contractor(s)	Construction Manager & PIU Manager	Included in project implementation cost

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
	No construction activities and transportation of construction materials will be taken up during night time					
Biodiversity of the project area and surroundings	Ensure no tree is felled during construction of the project site, access road and grid connection Ensure that there is no burning of wood or cutting of unauthorized trees from the project area and surroundings by the construction workers for cooking or heating Workers will be trained not to hunt the local fauna. They will be trained not to fish in the Wong Chu River or its tributaries	Removal of vegetation during site clearing	During entire construction phase	Contractor(s)	Construction Manager & PIU Manager	n/a
Compensation for land acquisition for access road	The compensation / substitute land will be provided before taking possession of the private land for the access road	Compensation /substitute land	Before start of construction work	Dzongkhag administration	PIU manager	Land acquisition cost, if any will be included in the project implementati on cost

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	**Supervision**	
Memorandum of understanding with land owner for the right of way for the overhead grid connection line	PIU will obtain a No Objection Certificate and will sign a memorandum of understanding to use the right of way	Obtaining the Certificate and signing the MoU	Before start of construction work	BPC	BPC	n/a
Common property resources and utilities	The contractor will ensure that there are no damages to common property resources (schools, BHU, ORC, water supply line, telephone cable/phone, electric supply line/cable) by transporting construction materials, wind turbines and machinery to the site (No common property resources currently exist at the project site and the access road land) It will be ensured that there will be no damage to 66 kV line and pylon near the project site	Safe transport of construction materials, wind turbines and machinery Safe work at construction site	Entire construction duration	Contractor(s) Contractor(s)	PIU manager PIU manager	Cost built into the implementati on cost Cost built into the implementati on cost

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
Traffic and transport	During transport of wind turbines from Phuentsholing to Chukha and then Chukha to Tsimalakha proper, traffic management plan will be prepared to minimize disturbance to normal traffic	During construction phase		Contractor	PIU manager	Part of the project implementati on cost
Aviation hazards	Although the project site is not in any flight path, to ensure that no such hazards exist, the blades will be marked with a red band so that these are more visible from a distance	Marking of red band on blades		Contractor	PIU manager	Part of the project implementati on cost
Availability of first aid kits at construction camp	The contractor will ensure the availability of 2-3 first aid kits at the construction camp and project site. They will include adequate sterilized dressing materials and medicines as per requirements.	Availability of dressing materials, and medicines	Entire duration of construction	Contractor(s)	PIU manager	Included in the project implementati on cost.

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
Occupational safety and health	The contractor will comply with all precautions required for the safety of workers according to applicable International Labour Organisation (ILO) Convention 62		Entire duration of contracts	Contractor(s)	PIU manager	Included in the project implementati on cost.
Public safety – unauthorized entry at site	The contractor(s) will barricade the construction site(s) at all times with adequate marking, flags, reflectors, etc. for the safety of general public and animals	Safe barricading of the site	Entire construction duration	Contractor(s)	PIU manager	Included in the project implementati on cost
Personal protective equipment (PPE) to all workers	The contractor will provide PPE such as helmets, safety shoes, masks, safety belt, and ear plugs to all staff and workers	Availability of personal protective equipment	Entire construction duration	Contractor(s)	PIU manager	Included in the project implement-tation cost
Accidental bird hits	To avoid accidental bird hits, the blades of the turbine must be made visible by having markings in red	Blades have red bands	Prior to installation of wind turbine blades	Contractor(s)	PIU manager	Included in the project installation cost

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
Safety measures in the project design and installation for earthquakes	The project design should have provisions for earthquake-resistant structures of different components.	Earthquake-resistant designs for the access road, wind turbine foundations, substation and wind mast	During project design	Design consultants	Contractor(s)	Included in the project implementation cost
Safety measures to avoid damage to the wind power pilot project components, especially turbine blades due to high winds	The wind turbines will be designed to stop moving when wind speeds exceed 25 m/s	Verification of this feature during procurement and acceptance of the wind turbines	Bidding condition	PIU	PIU manager	Inclusion in the project procurement cost
B: Operation Phase						
Ambient air quality	The operator will ensure that all vehicles and machinery used for maintenance and inspection comply with the emission standards of the NEC	Excessive exhaust smokes	During operation	Project operator	PIU manager	Included in the project operation cost
Surface water quality and consumption	The operator will arrange water for irrigation of the green belt in non-monsoon months at the wind power plant site	Survival of trees	Initial two years	Project operator	PIU manager	Included in the plant operation costs
Ambient noise levels in the project vicinity	Noise levels will be measured by the project operator at the nearest house, located at 250 m from the project site and at Tsimalakha village. In case noise levels are found to exceed the	Ambient noise levels according to the national ambient noise standards for day and night time	First year of the project operation	Project operator	PIU manager	Included in the EMP cost

Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
	national standards, then noise mitigation measures in the form of noise barriers will be constructed on three sides of the nearest house (north, south and west). Green belt will be developed along the eastern boundary of the project site to attenuate noise levels	Monitoring of survival rate of trees planted for green belt development				
Biodiversity	Shrubs will be planted on the side slopes of the access road A green belt will be developed on the eastern boundary and shrubs planted along the internal roads of the project site	Plantation and shrubs survival	First 2 years	Contractor	PIU manager	Included in the EMP budget
Erosion at road embankment and cut section	Visually observe any erosion in road embankments during monsoon; rectify erosion if observed. Shrubs planted to counter the erosion problem	Erosion at side slopes and cut section	Every year during monsoon	Project operator	PIU manager	Included in the project operation cost
Safe access to plant site	The project site will be fenced with barbed wire to prevent unauthorized access and animals entering the project site	Maintenance of barbed wire fencing	Entire operation phase	Project operator	PIU manager	Included in the project operation cost

Table I-14: Environmental Management Plan Budget				
S. No	**Item**	**Quantity**	**Rate**	**Amount (Nu)**
1	Construction of noise barriers on three sides of the nearest house	150 m	Nu 500 per meter	75,000
2	Procurement of a integrated digital noise meter	1	Nu 150,000	150,000
3	Planting of shrubs on side slopes of the access road and along the boundary the project site	1000	Nu 200	200,000
4	Development of green belt along the eastern boundary of the project site	1000	Nu 500	500,000
Total				925,000
	Contingency		5 %	46,250
Total Budget				**Nu 971,250**

11.3 Conclusion

238. The wind power pilot project will not result in any long-term significant adverse environmental impacts. The implementation of the EMP will ensure that all environmental impacts will be within the acceptable levels.

239. Based on the environmental assessment activities conducted, the proposed wind power pilot project is confirmed as Safeguard Category B for environment and involuntary resettlement, and the IEE, including the EMP, is sufficient to meet the environmental assessment requirements of ADB and the RGOB. A full environmental impact assessment study is not required.

Appendix J

INITIAL ENVIRONMENTAL EXAMINATION FOR THE BIOGAS PILOT PROJECT COMPONENT

1. EXECUTIVE SUMMARY

1. **Need for the Project.** In Bhutan, fuelwood is still rural households' predominate use for cooking; liquefied petroleum gas (LPG), kerosene and electricity are widely used for cooking by urban households (90%). Fuelwood consumption contributes to deforestation, greenhouse gas emissions, and smokes, with adverse health effects on households. LPG, kerosene and other fossil fuels are imported as Bhutan does not have any known fossil fuel resources. It is thus necessary to explore the possibility of other energy sources. The biogas pilot project is a step in this direction.

2. **Objectives.** The objectives of the proposed biogas pilot project are to 1) improve access to modern household cooking using clean, renewable biogas, 2) reduce greenhouse gas emissions, and 3) reduce deforestation. Additional benefits of the proposed project include 2) a reduction in adverse health effects from indoor air pollution resulting from firewood smokes, 2) a positive social impact as the time spent on collecting firewood will be reduced, and 3) an improvement of farmers' crop yields by using the organic byproduct from biogas plants.

3. **Location.** The proposed project aims to assist farmers in southern and eastern Bhutan – Chukha, Samtse, Sarpang, Tsirang, Mongar, Samdrup Jongkhar, Pemagatshel, and Trashigang – to install biogas plants to improve their livelihoods. During the 2011 to 2014 period, the proposed pilot project will promote and market biogas plants to farmers in Chukha, Samtse, Sarpang and Tsirang dzongkhags who own at least five cattle and live in areas with not too cold a climate and favorable terrain. The target numbers of biogas plants are: 50 units in 2011, 100 units in 2012, and 1,000 units in 2013/2014. The project is expected to be continued and scaled up to include farmers in other four additional dzongkhags in subsequent phases if the pilot project is successful. The specific locations of the target biogas plants will not be known until the project is implemented, promotional and marketing programs are launched, and interested farmers have submitted applications to the Project Implementation Unit (PIU).

4. **Initial Environmental Examination (IEE).** The IEE was included in the project's preparation to streamline environmental issues in biogas pilot project implementation. The IEE report has been prepared as per ADB *Safeguard Policy Statement 2009*.The IEE preparation led to the identification of potential environmental impacts during the construction and operations phases, and the preparation of an Environmental Management Plan (EMP) to mitigate the negative impacts identified.

5. **Category of the Project.** The biogas pilot project has been categorized as Category B, as there are no significant adverse impacts during the construction and operation phases. On the contrary, the project is environment friendly as it will reduce firewood consumption and hence, deforestation will be decreased.

6. **Project Details.** The proposed biogas plants use cattle dung to produce biogas that is clean and renewable with bio-slurry as the byproduct. Biogas plants in the proposed project will use the Gobar Gas Company designs that have been widely used in Nepal and Laos, and successfully pilot tested in Bhutan. The plants will be constructed by masons using locally available stones, aggregates, sand pipes, and fittings. A biogas plant consists of 1) an inlet (less than 1 meter in diameter), 2) an airtight digester mostly in the range of 4 to 8 cubic meters, and 3) compost pits (typically 1 meter by 2 meters by 3 meters). All the components except the inlet where dung and water are mixed and fed into the digester are built underground within the household's premises. The biogas produced in the digester tank is piped to the household's kitchen for use on demand. The byproduct, i.e., bio-slurry stored in the underground compost pits, is an odorless organic fertilizer.

7. **Implementing and Executing Agencies.** The implementing agency (IA) for the biogas program will be the Department of Livestock (DOL) under the Ministry of Agriculture and Forests. A Project Implementation Unit (PIU) will be established at the DOL specifically for the management of the project; it will liaise with the selected financial intermediary. The Department of Energy of the Ministry of Economic Affairs will be Executing Agency (EA) for the biogas pilot project. A high-level Biogas Advisory Committee to be chaired by the Director General of the DOE; it will provide overall policy guidance and oversight of the pilot project's implementation.

8. **Policy, Legal and Administrative Framework.** In Bhutan environmental protection has been entrusted to the NEC. The Royal Government of Bhutan has enacted a number of Acts and Rules such as the Forest and Nature Conservation Act 1995 and Forest and Nature Conservation Rules 2000. The biogas pilot project does not require environmental clearance, as this is not included in the list of projects requiring environmental clearance. But on the advice of the NEC, a concept paper containing a project profile, impacts, mitigations and environmental management plan was prepared and submitted to the NEC. Subsequently, the NEC issued an environmental clearance for the project.

1.1 Description of the Environment

Physical Environment

9. The determination of baseline conditions is a pre-requirement in the preparation of IEE reports. The prevailing baseline status is described in the following sections.

10. **Topography, Geology and Soil.** The topography of the project areas is partly hilly and partly flat. The elevation of the project areas ranges from 200 m to 4,500 m.

11. All eight 8 dzongkhags in the project areas fall within the Lesser Himalayan formation. This includes a wide range of sedimentary and low-grade metamorphic rocks, including argillites and metargillites, sandstones and quartzites, limestone, dolomite and gypsum.

12. The soil types found in all of the dzongkhags range from sandy, clay, loam to sandy loam and clayey loam. Generally, the soil in the alluvial lowland river valleys is quite fertile and crops grow well as soil moisture is also adequate in the foothills. At lower altitudes, many of the slopes are covered with colluvium, a mixture of soil and stones deposited by slow creep and many small landslips and slumps.

13. **Climate.** All dzongkhags of the project areas except Trashigang are located in the subtropical zone as these are near foothills. The climate of Trashigang is temperate. The summers are hot and humid, especially from July to September, with temperatures reaching as high as 30° C, while the winters are dry and cool with temperatures dropping to as low as 13° C in December and January. The relative humidity ranges between 55% and 82%.

14. The average annual rainfall ranges from 1,500 mm to 5,000 mm, but sometimes the precipitation becomes much heavier. The precipitation is heaviest during the months from June to September.

15. **Ambient Air Quality.** Ambient air quality monitoring is not being done in the project areas. The NEC is monitoring air quality at Phutensolling and Thimphu only. The concentrations of inhalable particulate matter and gaseous pollutants at both locations are within the limits set by the NEC. In the project area, ambient air quality is expected to be better as there are less pollution-generating traffic and fewer commercial activities.

16. **Surface Water Resource and Quality.** Each dzongkhag in the biogas pilot project areas has perennial rivers that drain the area. The prominent stream are Jeri Chu, Uri Chu in Pemagashtel; Drangme Chu in Trashigang Chu; Trashigang and Deu Chu in Samdrup Jongkhar; Maokhola, Shetikahray and Dawalakhola in Sarpang; Wong Chu in Chukha; Manas in Mongar; and Sankosh in Tsirang. Smaller streams that join these rivers in the respective dzongkhags. Surface water quality data for the project areas are not

available, but the areas are thought to be pristine as there are no pollution discharge sources to these rivers.

17. **Groundwater Resource and Quality.** There are no data available on the areas' groundwater resources. These resources are abundant, with springs emerging from underground rocks, old landslides and fluvial deposits. Groundwater in landslide and alluvial deposits has been estimated at an exploitable rate of 3 liters per second per km^2. Generally, the state of Bhutan's groundwater quality is still good, but with expanding settlement along rivers there are localized pollution problems. In the project areas, water quality is anticipated to be good.

18. **Noise.** Data on measured noise levels are not available in the project areas as currently the NEC is measuring noise levels at Phuentsholling and Thimphu only. Major contributors to ambient noise are commercial activities and vehicular traffic. The project areas have less traffic and commercial activities, so the noise level is expected to be within the stipulated limits of the NEC for rural and residential areas (55 dB (A) during the day and 45 dB (A) at night.

19. **Aquatic Environment.** There are 41 species of fishes in the rivers and lakes of Bhutan. They include eight exotic species like the coldwater trout, and seven other species introduced for warm water aquaculture.

Ecological Resources

20. **Protected Areas.** The eight dzongkhags (four in the proposed pilot project phase and four in the subsequent phase) where biogas plants are to be promoted have three protected areas: Jigme Singye Wangchuk National Park (JSWNP), Royal Manas National Park (RMNP) and Phibsoo Wildlife Sanctuary. These protected areas fall in Sarpang, Tsirang and Pemagashtel dzongkhags. JSWNP has 1,723 km^2 areas and is habitat to 395 species of birds and 22 of mammals. RMNP has an area of 1,023 km^2 and it is habitat to 362 bird species. Phibsoo has an area of 278 km^2 and besides wildlife; it is famous for its natural Sal forest. Biogas plants will not be established in habitations in these protected areas.

21. **Forest and Flora.** The dominant forest type in all eight dzongkhags is broadleaf, accounting for 30% to 95% of the total forest areas. The second dominant category of forest is mixed conifer forest. The forests in the protected areas mainly comprise subtropical forests, warm broadleaved forest and cool broadleaved forests.

22. **Wildlife.** Wildlife has been reported in forest areas. There are 76 species of fauna found in the forests of the project areas. These are listed in the report. Biogas plants will be installed only in the habitations where no wildlife is expected.

Economic Development Resources

23. **Land Use, Industries and Agriculture.** The forest cover in the dzongkhags selected for

biogas pilot project ranges from 53.6% (Pemagashtel) to 88.5 % (Mongar). The cultivable area is less than 15% in all eight dzongkhags, except Pemagashtel, where it is 45%. The other land uses are under pastures, water bodies, rocky area and settlement. The area under settlement is less than 0.12% in all dzongkhags of the biogas pilot project.

24. Major crops produced in the project areas include maize, wheat, buckwheat, barley, mustard, finger millet and foxtail millet along with a wide variety of green vegetables. While orange is grown in almost all southern dzongkhags of the country, cardamom, areca nut, ginger, guava, lemon, banana and mango are also grown extensively.

25. Most of the existing industrial establishments in Bhutan are small-scale or cottage industries. In the project areas, industries exist in Samtse and Sarpang. There is good growth potential for industries in Gelephu.

26. **Administrative Infrastructure and Community Facilities.** All dzongkhag headquarters in the project areas, namely Samdrup Jongkhar, Sarpang, Chukha, Damphu, Pemagashtel, Mongar and Trashigang, have dzongkhag administrative offices such as a Forest Department, Revenue Department, courthouse, etc. There are also amenities such as banks, post offices and communication centers.

27. Community facilities such as schools and health clinics, exist at the Gewog and dzongkhag level. Almost 50% of the population has access to piped water supply.

28. **Transportation.** All dzongkhag and Gewog headquarters in the project areas are connected by road. The remote villages are connected by mule tracks. There is no other type of transport such as air and rail in the project areas.

29. **Electricity and Communication.** The households close to dzongkhag headquarters have been electrified. According to the information available on dzongkhag websites, the numbers of households electrified are 244 in Samdrup Jongkhar, 1,563 in Samtse, 741 in Mongar, 1,547 in Pemagashtel, 2,197 in Sarpang, 2,500 in Trashigang, 1,194 in Chukha, and 1,188 in Tsirang.

30. All dzongkhag headquarters are connected by line telephone. All dzongkhag towns have mobile phone connectivity.

31. **Tourism Potential.** At present, all eight of the dzongkhags have a poor tourism potential due to lack of infrastructure facilities. In future, Gelephu may become a tourist destination.

Social and Cultural resources

32. **Demography.** The population of Bhutan includes many ethnic groups such as the Sharchops in the east, Ngalongs in the west, Khengpas in the central region, nomads in the north

and Lhotshampas in the south. The majority of the population is Buddhist (around 70%) and the remainder is mainly Hindu, mostly in the southern areas.

33. The project areas have a sex (male/female) ratio of 1:1. In the project areas about 70% of the population is rural residents while 30% is urban dwellers. The average number of family members per household is 4.56 in the project areas. The percentages of male and female employed are 52% and 18%, respectively. The overall employment percentage is 35% in the project areas. Around 73% of the households in the project area own land, 57% own their home, 8% own their own business, and 7% own a vehicle.

34. **History and Cultural.** None of the dzongkhags selected for biogas plant installation have historical or cultural monuments of heritage importance that may be affected by the proposed pilot project.

1.2 Environmental Impacts and Mitigation Measures and Benefits

35. No impacts on the ecologically sensitive and protected areas, including JSWNP and RMNP, and Phibsoo Wildlife Sanctuary are expected. The other environmental attributes where no impacts have been identified from the proposed pilot project are topography, geology, soil, water supply, ground and surface water resources and quality, flora and fauna.

36. Minor impacts have been identified on the ambient air quality of the project area during construction due to dusts generated from material handling and other construction activities. There will be no impact on air quality during the operation of the biogas plants.

37. Minor impacts have also been identified on noise levels during construction. These will be confined within the owner's housing premises.

38. During the operation phase biogas may leak and if there is an ignition source in the vicinity, fire may result.

39. There will be no impact from the construction and operation of biogas plants on the public utilities such as water supply lines, electrical cables/poles, and telephone poles, as these are not required to be shifted. The water requirements for construction and operation will be met from the allocated water supply of the farmer.

40. During the operations phase there may be generation of flies, insects, worms and mosquitoes, if there is an unexpectedly long downtime.

41. Impacts on air quality during construction will be mitigated through water spraying during construction. All construction materials will be stored by the farmer indoors or covered if stored outdoors.

42. During the construction phase, no construction works will be carried out in night hours (2100-0600 hours) to avoid any adverse noise impacts.

43. In order to minimize biogas leakage incidents during the operations phase, farmers will be trained by the PIU on efficient and safe operations. The training will cover leak prevention and fire protection/control of biogas plants.

44. To minimize the generation of flies, worms, mosquitoes and insects during operation, the PIU will minimize any down time by the prompt resolution of complaints on plant performance. In addition, the proposed pilot project will require a two-year warranty by masons on all construction works.

45. The proposed biogas pilot project will produce biogas that is a clean, sustainable renewable energy source to replace use of fuelwood and fossil fuel. The environmental and social benefits of the pilot project include:

- Reducing the consumption of fuelwood for cooking will reduce deforestation, greenhouse gas emissions, and smoke-related health problems, especially for children and the elderly, caused by smokes from burning of fuelwood
- Cutting down on the consumption of LPG and kerosene for cooking will reduce the nation's need for importing fossil fuels
- Diversifying energy resources and enhancing the nation's long-term energy security
- Promoting stall feeding of cattle to minimize forest grazing, which contributes to environmental degradation
- Providing an innovative way of minimizing and managing cattle dung in an environmentally and economically beneficial manner
- Creating business opportunities for supply, installation, and services of biogas plants and spare parts
- Increasing farmers' ability to generate additional incomes from other activities by freeing their time from fuelwood collection, cleaning smoke-blackened utensils and disposing of cattle dung
- Improving agriculture crop production through the use of organic manure and encouraging organic vegetable and fruit farming
- Serving as one of the complementary business opportunities for the country's dairy farmers cooperatives.

1.3 Analysis of Alternatives

46. Three possible alternatives have been considered; the comparative analysis is summarized in Table J-1.

Table J-1: Comparative Analysis

Parameters	No Project Scenario	Project Scenario	Other Form of Energy Scenario (Electricity)
Economic cost	Financial cost incurred on firewood collection is minimal, time spent on collection significant, and permit from the Forest Department becomes increasingly difficult to obtain	Considerable time will be saved on firewood collection The scheme will be financially attractive to participating farmers due to the subsidy and below-market loan provided	High cost-electricity supply for cooking and heating is beyond the affordability of farmers/rural population.
Developmental impacts & people's perceptions	Village/gewog considered underdeveloped	Community will be considered developed	Community will be considered developed.
Social benefit	Households will be exposed to smoke, dirt, and increasing distance/time spent on firewood collection	Clean and renewable energy The energy can be used for cooking and heating	Electric energy is also a clean form of energy Electricity supply at many remote isolated villages not possible due to difficulty in extending grid
Environmental impacts	Yearly increase in firewood consumption and deforestation	No adverse environmental impacts Greenhouse gas emissions will decrease Organic manure will increase crop productivity Reduced cutting of trees	Extending grid will involve cutting trees in the right of way of the grid. This will have negative impacts on forests
Health	Negative impact on health due to smoke and dirt generation	Positive impact on health as biogas is a clean form of energy	Positive impacts on health

47. Based on the comparison of these alternatives, the proposed project is the best alternative for the current situation.

1.4 Public Consultations and Information Disclosure

48. Public consultations were carried out at the inception stage of the proposed project to disseminate information on the project and seek suggestions for project design. The consultations were carried out at the institutional, local, and dzongkhag levels. These are summarized in Table J-2.

Table J-2: Public Consultations

S. No.	Date of Consultation	Level of Consultation	Organizations/Public Invited/Contacted for Consultation	Objectives of Consultation
1	04-12-2009	Inception workshop by PPTA consultants	NEC, DOL, Ministry of Agriculture and Forests, Ministry of Economic Affairs, SNV Bhutan	Inception workshop was organized to invite views, comments and suggestions on the project
2	08-12-2009	Institutional	NEC for environmental clearances	NEC officers suggested to submit a concept paper instead of an IEE to get the environmental clearance for the project as there are no adverse environmental impacts involved
3	17-01-2010	Local level	Chaskar at Mongar Dzonkhag	To inform the public about the project and invite their comments and suggestions
4	19-01-2010	Local level	Gumang Shumar Geog (Pemagatshel)	To inform the public about the project and invite their comments and suggestions
5	19-01-2010	Local level	Samdrup Jongkhar	To inform the public about the project and invite their comments and suggestions
6	20-01-2010	Local level	Patbari Sompangkha in Sarpang Dzonkhag	To inform the public about the project and invite their comments and suggestions
7	22-01-2010	Local level	Tsholingkhar Geog	To inform the public about the project and invite their comments and suggestions
8	23-01-2010	Local level	Pam at Trashigang	To inform the public about the project and invite their comments and suggestions
9	28-01-2010	Local level	Tsakling	To inform the public about the

Table J-2: Public Consultations				
S. No.	**Date of Consultation**	**Level of Consultation**	**Organizations/Public Invited/Contacted for Consultation**	**Objectives of Consultation**
				project and invite their comments and suggestions

49. The comments, suggestions and concerns of public and the way in which they were considered in the project preparation are summarized in Table J-3.

Table J-3: Summary of Responses to the Issues Raised in Public Consultations	
Issue/Concern Raised	**Responses/Comments Provided**
In most local consultations, villagers stated that self-financing is not feasible	The project has been designed with a below-market loan and subsidy to help farmers overcome the financial barriers to investment in biogas plants
The villagers stated that local masons cannot construct biogas plants properly; thus, construction should be arranged by the government	The PIU will train on villagers the construction of biogas plants and issue certificate if they pass the tests. The quality of construction will be supervised and inspected by the PIU
Collection of firewood is a problem because it involves time and energy and permits from the Forest Department are becoming more difficult to obtain	The biogas plants will substantially reduce the time and effort of farmers spent on firewood collection.
The biogas plants installed in the past did not function properly. Due to this, some participants were sceptical about biogas investment	The project will use biogas plant designs successfully tested in Bhutan and require the contractor to provide a two-year warranty. The PIU will also provide training to the owners on the operation and maintenance of biogas plants. Thus, the technical risks will be minimal.
A model biogas plant should be installed at the Gewog level for demonstration, then people will install them at the individual level	The project will be implemented in phase to ensure all the biogas plants in the initial year are successful and then gradually scale up in subsequent years
Common biogas plant should not be installed as it did not work properly at Punakha	The project aims to install individual household biogas plants, not common biogas plants

50. At the institutional-level consultations, all the participants welcomed the project as it will provide clean energy and will reduce deforestation.

1.5 Grievance Redress Mechanism

51. The biogas pilot project does not involve any acquisition of land and there is no cutting of trees. Public complaints against the biogas plants are not anticipated as biogas plants will be built in private properties in backyard of each owner's house. The complaints related to construction quality will be addressed by masons, as all plants will have a two-year warranty by the masons. The masons will be trained by the PIU on the construction of biogas plants. In case owners raise other types of complaints, they will be addressed by the DOL extension officer in the Gewog within one week. The extension officer will send information to the PIU after resolving the complaint. In case the complaint is not resolved by the extension officer, then he or she will forward the complaint to the PIU at Thimphu for resolution. The PIU will address the complaint within two weeks. Any unforeseen complaint related to the environment will be received by the PIU directly or through Gewog/dzongkhag extension officers. The quality control officer of the PIU will resolve the complaint within two weeks. The PIU will adopt an open door policy for suggestions by the public on improving the performance of biogas plants and to make them popular among the masses.

1.6 Environmental Management Plan

52. The Environmental Management Plan includes specific mitigating measures for the identified negative impacts. For each mitigating measure to be taken, the EMP will include its location, timeframe, implementation and oversight/supervisory responsibilities.

53. There is no exclusive EMP cost as this has been built-up into the other project implementation costs.

1.7 Findings, Recommendations, and Conclusion

Findings

54. The findings of the IEE are as follows:

- The biogas pilot project is environment friendly as it will reduce deforestation from reduced firewood consumption for cooking. The quality of life of participating rural farmers will improve, as it is a clean fuel with no generation of smoke.
- None of the biogas plants will be built in habitations that are located within the ecologically fragile areas such as national parks, wildlife parks, wildlife sanctuaries, or biological corridors.
- The environmental impacts identified are dust generation during construction and the generation of flies, insects and worms from cattle slurry during unexpected downtime of the biogas plant in the operations phase.
- All impacts will be manageable to an acceptable level as there will be the PIU for regular inspection and training of farmers.
- The organic manure available from biogas plants will increase the crop productivity of the farmer.
- Mitigation and monitoring measures with cost estimates have been developed in the EMP. The EMP will be implemented by the PIU and masons, with oversight by the DOL, DOE, government regulatory agencies, and ADB. Public consultations were undertaken during project preparation. The PIU will follow an open door policy for receiving complaints, if any, from concerned farmers, and will conduct additional consultations as necessary during project implementation.

Recommendations

- The IEE recommends that no biogas plants be built in habitations that are in ecologically sensitive areas.
- A maintenance and inspection schedule should be formulated by the PIU so that downtime of biogas plant is minimal.

Conclusion

55. No biogas plants under the proposed pilot project will be in the environmentally sensitive areas. The project will not result in any long-term significant adverse impacts. Minimal negative environmental impacts are anticipated, mostly during construction. These can be mitigated successfully by implementing the EMP. Environmental and social benefits of the project and long-term renewable energy development objectives outweigh the negative impacts.

2. INTRODUCTION

56. With many other Asian countries successfully promoting biogas, the Royal Government of Bhutan (RGOB) is proposing a biogas pilot project. The Department of Livestock (DOL) of the Ministry of Agriculture (MOA) will be the implementing agency, and the Department of Energy (DOE) of the Ministry of Economic Affairs (MOEA) will be the executing agency for the proposed biogas pilot project.

57. The Initial Environmental Examination (IEE) was carried out to identify and assess the potential environmental impacts from the implementation of the proposed biogas pilot project in rural areas to replace firewood and kerosene for cooking and heating. The proposed pilot project will not involve any land acquisition or displacement of people as biogas plants will be constructed on private land near the houses of participating farmers. The current legislation of the RGOB does not require an environmental impact assessment study for the implementation of the biogas pilot project. The proposed pilot project was determined as Category B based on the Rapid Environmental Assessment described in the ADB's *Environmental Assessment Guidelines* (2003) and ADB's *Safeguard Policy Statement* 2009. This IEE was prepared in accordance with ADB *Safeguard Policy Statement* 2009 with due consideration to environmental legislation of the Royal Government of Bhutan.

58. The IEE was prepared to meet the following objectives:

- To provide information about the general environmental settings in the targeted dzongkhags of biogas plants in the country
- To provide information on potential impacts of the proposed pilot project and the characteristic of impacts (magnitude, distribution, and duration)
- To provide information on potential mitigation measures to minimize the identified impacts
- To provide information on Environmental Management Plan (EMP)
- To meet the ADB requirements for biogas pilot project financing.

59. Field visits were made to collect the requisite information from various government departments and other secondary sources (including public consultations).

3. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.1 Policies Relevant to Biogas Component

60. The Royal Government of Bhutan has enacted a number of Acts and Rules to safeguard the country's environment . These Acts and Rules are reviewed in the following subsections.

3.2 Electrification Act 2001

61. Rural electrification is strongly promoted in the Electricity Act, 2001. Part 7, Section 61.1 states that ”The Minister shall undertake to promote, support and provide rural electrification programmes through public and private sector participation in order to:

1. achieve equitable regional distribution and access to electricity;
2. maximize the economic, social and environmental benefits of rural electrification subsidies;
3. promote extension of the grid and development of off-grid electrification; and
4. promote renewable energy.”

This biogas pilot project will help achieve the aim of the Act for harnessing the renewable energy from the cattle dung.

3.3 Forest and Nature Conservation Act (FNCA) 1995

62. The Forest Act (1969) was the first environmental legislation in Bhutan and brought all forest resources under government custody to regulate their utilization. It was repealed with the enactment of the FNCA in 1995, which allows community stewardship of forests, and aims to provide protection and sustainable use of forests, wildlife, and related natural resources. Schedule I lists those wild animals and plants that are given full protection under the Act. The trees listed in the Schedule are not expected at the locations of biogas plant sites as these will be inside farmers’ homes. The FNCA establishes that all forests in Bhutan are Government Reserved Forests (GRF), and prohibits any development activity in these areas except with a permit. This Act will not be applicable to the biogas pilot project.

3.4 Forest and Nature Conservation Rules (FNCR) 2000

63. Under powers established by the FNCA, the Ministry of Agriculture promulgated the FNCR in 2000, which was revised in 2006. Among other things, the FNCR allows for:

- Allotment of land and land rights in GRF
- Prohibitions, restrictions and concessions in GRF
- Transport and trade of forest produce
- Declaration and administration of protected areas
- Protection of wildlife and use of certain wild species
- Prevention of forest fires, land clearance, and activities potentially impacting soil, water and wildlife resources
- Enforcing penalties for offences related to these and other aspects of the

FNCR.

64. None of these activities prohibited by the Rules will be taken up under the biogas pilot project.

3.5 Protected Areas

65. Since 2008, five national parks, four wildlife sanctuaries and one strict nature reserve have been established in Bhutan. The RGOB's policies mandate that all proposed development projects within the boundaries of the protected areas will be subject to an EIA under the jurisdiction of the NEC. This requirement also applies to the buffer zones outside the protected areas, and the biological corridors as stipulated in a 2006 addendum to the FNCR.

66. Biological corridors (BC) are defined as "areas set aside to connect one or more protected areas, which shall be conserved and managed for the safe movement of wildlife." Although BCs do not have the same status as protected areas, activities such as new settlements, quarrying and mining, and leasing of land for grazing are prohibited. All other development activities, including the construction of roads, electricity transmission and distribution lines, or any other structures, require a permit from the DOF and an EC application to the NEC, supported by an EIA. The establishment of biogas plants and associated activities during construction and operation will not be taken up in BCs and protected areas; therefore, no impact is anticipated on these protected areas.

3.6 Land Act 1979 (Revised 2007)

67. The Land Act 1979, which provides the basis for land tenure in Bhutan, was revised in 2007 to streamline the provisions in the Land Act. One major change was the establishment of an autonomous National Land Commission Secretariat, which has been given full responsibility for all matters pertaining to land registration. Also the 20 land categories have been reduced to seven categories in the revised Act including 1) *chhuzhing* (wetland), 2) *kamzhing* (dry land) including orchard, 3) Khimsa (residential land), 4) industrial land, 5) commercial land, 6) recreational land, and v7) institutional land.

68. Powers over land management have now been decentralized to local authorities like the Gewog Tshogdue, dzongkhag Tshogdue, and Thromdes. These local authorities are empowered to resolve land disputes, and endorse land transactions and conversion of land categories.

69. Under this Act, there are provisions for acquisition of land by the government, if

it is required for the benefit of the country. In such cases, the affected persons will be compensated with substitute land from the same dzongkhag or given cash compensation depending on the land classification and the prevailing land compensation rate determined by the Act. If a house is acquired, compensation is paid on the basis of an evaluation carried out by a qualified engineer appointed by the competent authority. No land acquisition is required by this biogas pilot project; therefore, this Act will not be applicable.

3.7 RGOB Decentralization Policy 2002

70. The Dzongkhag and Gewog Yargay Tshogdue Acts were implemented in 2002 to support the government's decentralization policy and empower locally elected community bodies (DYTs and GYTs) with the authority and responsibility to plan and implement development programs and activities, including those related to environmental management. Through this legislation the DYT is able to:

- Make recommendations on activities with major environmental impacts
- Designate and protect sites and monuments of cultural or historical interest
- Designate and protect areas of special scenic beauty or biodiversity, such as dzongkhag parks and sanctuaries
- Establish and enforce regulations to control noise pollution
- Prohibit the construction of structures within 50 ft of highways.

The GYT is able to establish and enforce regulations to:

- Control and prevent pollution of air, soil and water
- Ensure safe disposal of waste and adequate standards of sanitation
- Conserve and protect water resources, including rivers, streams, springs and lakes.

The GYT also has custody of communal lands and community forests and can prevent encroachment onto land and forest.

71. This policy will not be triggered by the implementation of this biogas pilot project as there will be no acquisition of land.

3.8 RGOB Environmental Clearance Procedure*s*

Environmental Classification

72. The environmental classification of projects is decided by the NEC on receipt of the Environmental Clearance (EC) application submitted by the project proponent. There are

three possible outcomes:

- The NEC may grant Environmental Clearance on the basis of the EC application if the application contains sufficient information and based on the information submitted, it is concluded that the proposed development will not have significant negative environmental impacts
- The NEC may deny Environmental Clearance on the basis of the EC application if the application contains insufficient information and it is clear that the proposed development will have significant negative environmental impacts that cannot be suitably mitigated
- If the EC application contains insufficient information on the likely nature and extent of the environmental impacts of the project or the manner in which they will be mitigated, the NEC will determine that an EIA is required.

Preparation of EC Application

73. The requirements of the EC application are set forth in the sectoral guidelines that were revised with ADB assistance in 2006. This biogas pilot project is not included in the list of activities requiring environmental clearance.

74. The information required for environmental clearance is very specific, and in all cases includes information on the applicant, the project, funding agency, the affected environment, potential impacts, mitigation, monitoring and public consultation. In the case of power transmission and distribution lines, information on impacts includes details of affected areas, types, uses and tenure of land; houses/infrastructure; protected areas; wildlife; cultural and heritage sites; etc.

75. There are three key elements of the EC application. These include the provision of signed No Objection Certificates (NOC) from all affected stakeholders/households, a forestry clearance from the Department of Forest and dzongkhag Administrative Approval.

3.9 Conclusion

76. Based on the above reviews, none of the government policies and Acts mentioned above is applicable to the biogas pilot project. The pilot project will help achieve the set objectives of the Rural Electrification Act 2001.

4. DESCRIPTION OF THE PROJECT

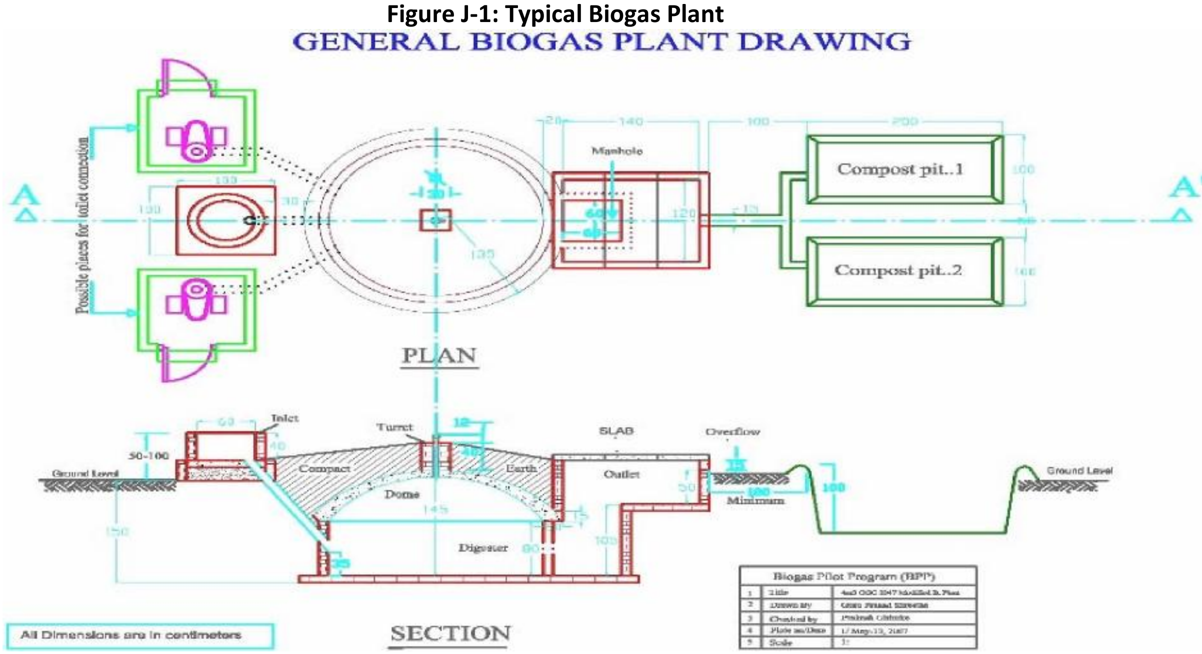
77. **Need for the Project.** In Bhutan, fuelwood is still predominately used for cooking by rural households; liquefied petroleum gas (LPG), kerosene and electricity are widely used for

cooking by urban households (90%). Fuelwood consumption contributes to deforestation, greenhouse gas emissions, and smokes with adverse health effects on households. All fossil fuels, including LPG and kerosene, are imported as Bhutan does not have any known fossil fuel resources.

78. **Project Objectives.** The objectives of the proposed project are to 1) improve access to modern household cooking using clean, renewable biogas, 2) reduce greenhouse gas emissions, and 3) reduce forest deforestation. Additional benefits of the proposed project include 1) a reduction in adverse health effects from indoor air pollution resulting from firewood smokes, 2) a positive social impact as the time spent on collecting firewood will be reduced, and 3) an improvement of farmers' crop yields by using the organic byproduct from biogas plants.

79. **Details of Biogas Plant.** The proposed biogas plants use cattle dung to produce biogas that is clean and renewable with bio-slurry as the byproduct. Biogas plants in the proposed project will use the Gobar Gas Company designs that have been widely used in Nepal and Laos, and successfully pilot tested in Bhutan. The plants will be constructed by masons using locally available stones, aggregates, sand pipes, and fittings. A biogas plant consists of 1) an inlet (less than 1 meter in diameter), 2) an airtight digester mostly in the range of 4 to 8 cubic meters, and 3) compost pits (typically 1 meter by 2 meters by 3 meters). All the components except the inlet where dung and water are mixed and fed into the digester are built underground within the household's premises. The biogas produced in the digester tank is piped to the household's kitchen for use on demand. The byproduct, i.e., bio-slurry stored in the underground compost pits, is an odorless organic fertilizer. The drawing of a typical biogas plant is given in Figure J-1.

Figure J-1: Typical Biogas Plant



80. **Location of the Project.** The proposed project aims to assist farmers in southern and eastern Bhutan – Chukha, Samtse, Sarpang, Tsirang, Mongar, Samdrupjongkhar, Pemagatshel, and Trashigang – to install biogas plants to improve their livelihood. During the 2011 to 2014 period, the proposed pilot project will promote and market biogas plants to farmers in Chukha, Samtse, Sarpang, and Tsirang dzongkhags who own at least five cattle and live in areas with a not-too-cold climate and favorable terrain. The target numbers of biogas plants are: 50 units in 2011, 100 units in 2012, and 1,000 units in 2013/2014. The specific locations of the target biogas plants will not be known until the project is implemented, promotional and marketing programs are launched, and interested farmers have submitted applications to the PIU. The program is expected to be continued and expanded to cover the four additional dzongkhags in a subsequent phase if the initial implementation in the 2011 to 2014 period proves to be successful.

81. **Cost of Biogas Plant.** Present estimates indicate that the average cost of a biogas plant of the capacity of $4m^3$ is Nu 26,000. This is the typical size of the plant, although there can be plants up to $10m^3$ that cost around Nu 36,800. Of the total cost of the plant, 45% will be advanced to the farmers in the form of a subsidy to help reduce the capital cost. The balance of 55% will have to be financed by the owner, either through equity or borrowings. It is estimated that the initial target group, the dairy farmers, will borrow up to 50% and advance the balance through their own resources. In all cases, the participating farmers will provide an up-front equity payment at least 27.5% of the total capital cost.

82. **Implementing and Executing Agencies.** The implementing agency (IA) for the biogas pilot project will be the Department of Livestock (DOL) under the Ministry of Agriculture and Forests. A Project Implementation Unit (PIU) will be established at the DOL specifically for the management of the project which will liaise with the selected financial intermediary. The Department of Energy (DOE) under the Ministry of Economic Affairs (MOEA) will be Executing Agency (EA). A high-level Biogas Advisory Committee will be established to provide policy guidance and oversight of the project's implementation. The Committee will consist of director generals of the DOE, DOL, Bhutan Finance Development Corporation, and SNV Bhutan, and will be chaired by the director general of the DOE.

5. Description of the Environment

5.1 Physical Resources

83. **Location.** The dzongkhags targeted for biogas plant installations lie in the southern and eastern parts of Bhutan bordering the States of Assam and West Bengal in India. The total geographical area of all the eight dzongkhags is approximately 16,074 square km. The total geographical area of the country is 38,394 square km.

84. There are about 40,000 households in all the eight dzongkhags and about 50% of those households are electrified. The shortest distance of the targeted dzongkhags from the capital city of Thimphu is around 90 km (Chukha) and the longest distance is about 500 km (Samdrupjongkhar). The prominent towns in these eight dzongkhags are Gelephu (in Sarpang dzongkhag); Samdrupjonkhar, Chukha, and Damphu (Tsirang dzongkhag) Trashigang, Sarpang, Mongar, Pemagashtel and Samtse. All these towns are the headquarters of dzongkhags except Gelephu. Due to its proximity to the Indian markets, Gelephu is the main center of commercial activities in the Sarpang dzongkhag. Samtse and Chukha dzongkhags extend to the Indian border (West Bengal State), whereas Samdrupjonkhar and Trashigang border with India's Assam State.

85. **Topography, Geology and Soil.** All the eight dzongkhags targeted for biogas plant installations lie in southern and eastern parts of the country with elevations ranging from 200 m to 4,500 m above sea level. Trashigang has the highest elevation at 4,500 m. On average, about 25% of the area in each dzongkhag is at 200 m to 600 m elevation. At the lower altitudes, the terrain is mostly flat or gentle, and agriculture is the main land use. The topography of all the dzongkhags extends to broad fertile valleys where agriculture and settlement are concentrated, especially near river banks.

86. The area size of the dzongkhag varies from 893 sq km (Pemagashtel) to 2,996 sq km (Trashigang). The percentage under forest cover in the dzongkhags targeted for biogas plants varies from 53.6 % (Pemagashtel) to 88.5% (in Mongar). About 10% is under agricultural production. Within the forested area broadleaf forest dominates with percentages ranging from 30% to 95%. The second dominant category of forests in the dzongkhags is Conifer.

87. All the dzongkhags fall within the Lesser Himalayan formation. This includes a wide range of sedimentary and low-grade metamorphic rocks, including argillites and metargillites, sandstones and quartzites, limestone, dolomite and gypsum. Gneisses underlie more than 70% of the country almost to the Indian border. The Shumar and Manas formations also exist in some dzongkhags such as Sarpang. The Shumar formation comprises alternating sequences of quartzite and phyllite/mica schist with bands of carbonate lenses of gypsum and sheet-like mylonitised granite gneiss as well as basic silts. The Manas formation comprises dolomite, limestone, phyllite and quartzite. Eastwards towards Gelephu and beyond, the quaternary conglomerate comprises mainly sand, silt and clay. The valley along the Sarpang-Tsirang road is dominated by argillaceous and arenaceous sediments, while the Saroang River areas are dominated by mica schist with prominent gritty bands of quartzite with thin carbonate intercalations towards the upper part.

88. The soil types found in all eight Dzonggkhags range from sandy, clay, loam to sandy loam and clayey loam. Generally the soil in the alluvial lowland river valleys is quite fertile and crops grow well as soil moisture is also adequate in the foothills. At lower altitudes, many of the slopes are covered with colluvium, a mixture of soil and stones deposited by slow creep and many small landslips and slumps.

89. **Climate.** All the dzongkhags except Trashigang are located in subtropical zones as they are near foothills. The summers are hot and humid, especially from July to September, with temperatures reaching as high as 30° C , while the winters are dry and cool, with temperatures dropping to as low as 13° C in December and January. The relative humidity ranges between 55% and 82%.

90. The average annual rainfall ranges from 1,500 mm to 5,000 mm, but sometimes the precipitation becomes much heavier. The precipitation is heaviest during the months from June to September.

91. **Air Quality.** Air pollution in Bhutan is a recent phenomenon and it can be attributed to rapid urbanization. Diesel vehicles are the major sources of urban air pollution. There is no information available on the ambient air quality of all eight dzongkhags because so far, ambient air quality (PM, NO_2 and SO_2) monitoring has only been conducted in Thimphu and Phuentsholing. The average inhalable particulate matter (PM_{10}) concentration of 24.5 ug/m3 in Thimphu is lower than the international PM_{10} standard of 40 ug/m^3. Since all eight dzongkhags have a much lower population and less construction and industrial activities and vehicles, the air quality is expected to be much better than that of Thimphu. Hence, air quality is not a concern in the project areas. Pollutants will be within the stipulated limits of the NEC if measured. The project will help improve air quality in dzongkhags as firewood smokes will be reduced.

92. **Surface Water Resource and Quality**. Each dzongkhag has perennial rivers that drain the area. The prominent streams are Jeri Chu, Uri Chu in Pemagashtel, Drangme Chu in Trashigang, Trashigang Chu, Deu Chu in Samdrup Jongkhar, Maokhola, Shetikahray Chu and Dawalakhola Chu in Sarpang, Wong Chu in Chukha, Manas in Mongar, and Sankosh in Tsirang. In addition, smaller streams join these rivers in the respective dzongkhags. During the monsoons the heavy rains often cause flash floods in the valleys, which are very vulnerable to erosion. The construction of embankments in erosion-prone areas and river diversion works are being undertaken as protective measures. Surface water quality data for the project area are not available, but it is known to be pristine because there are no known pollutants discharged to these rivers.

93. **Groundwater Resource and Quality.** There are no data available on the areas' groundwater. Groundwater resources are also abundant with springs emerging from underground rocks, old landslides and fluvial deposits. Groundwater in landslide and alluvial deposits has been estimated at an exploitable rate of 3 liters per second per km^2. Generally the state of Bhutan's groundwater quality is still good, but with expanding settlement along rivers, there are localized pollution problems.

94. **Noise.** Data on measured noise levels are not available in the project area as currently the NEC is measuring noise levels at Phuentsholling and Thimphu only. Major contributors to the ambient noise are commercial activities and vehicular traffic. Because the project area has less

traffic and commercial activities, ambient noise levels are expected to be within the stipulated limits of NEC for rural and residential areas (55 dB(A) during the day, and 45 dB(A) at night).

95. **Aquatic Environment.** A total of 41 indigenous fish species are known to occur in the rivers and lakes of Bhutan. These include eight exotic species like the coldwater trout, and seven species introduced for warm water aquaculture such as grass carp (ctenopharyngodon idella), common carp (cyprinus carpio), silver carp (hypothalmicthys molitrix), catla (catla catla), rohu (labeo rohita), and mrigal (cirrhius mrigala). Some of the fish species found in the river in Sarpang are schizothorax progastus (asla), schizothorax moleworthii, acrossocheilus hexagonolepis, crossocheilus latius, tor putitora (mahseer), tor tor (mahseer), barilius barna, barilius bendelisis, puntius macropogon, puntius sophore, puntius ticto, puntius titus, barbus spp., labeo dero, garra annandalei, garra gotyla, danio aequipinnatus, danio dangila, brachydanio rerio, botia dario, rasbora daniconius, noemacheilous botia, batasio, mystus bleekeri, mystus vittatus, ompok pabda, channa striatus and mastacembelus armatus.

5.2 Ecological Resources

Protected Areas

96. Three protected areas lie in the targeted eight dzongkhags: Jigme Singye Wangchuk National Park, Royal Manas National Park and Philbsoo Wildlife Sanctuary. The proposed pilot project will install no biogas plants in the villages in these protected areas. The brief description of these protected areas is given below.

97. **Jigme Singye Wangchuck National Park.** This park (1,723 km^2) is located in the central part of the country and connected to the Royal Manas National Park to the south. It encompasses parts of Trongsa, Zhemgang, Wangduephodrang, Tsirang and Sarpang dzongkhags. With altitudes ranging from 1,500 m to 4,500 m, this park also covers a wide range of ecosystems from permanent ice peaks, alpine lakes and pasture to conifer and broadleaf forests. This park is famous as the habitat of the threatened migratory black-necked cranes, the white-bellied heron, rufous-necked hornbill, satyr tragapan, and ward’s trogon. About 22 mammal species have been recorded in this park including several endangered species such as tiger, common leopard, clouded leopard, Himalayan black bear, musk deer, red panda and golden langur. As many as 395 species of birds have been recorded during surveys of which a number of species are of conservation interest. Around 5,000-6,000 persons live within the park and another 10,000-1 5,000 persons live within 3-5 km of the park boundary (NCD, 2004).

98. **Royal Manas National Park.** This 1,023 km^2 national park is adjacent to Jigme Singye Wangchuck National Park and to the south it forms a trans-frontier reserve with India’s Manas. It provides habitat for globally endangered species such as tiger, rhinoceros, elephant, leopard, gaur and pigmy hog and endemic species such as golden langur. 362 species of birds were observed in the park, 9 of which are globally threatened (NCS, 1995). Parts of Sarpang fall

within this national park, and Pemagatshel dzongkhag falls in the buffer zone of the park.

99. The Royal Manas National Park is one of the most well known national parks in Bhutan. It is famous because it forms a trans-frontier reserve with India's Manas, which is a world heritage site. At the same time, being adjacent to Jigme Singye Wangchuck National Park, it provides contiguous habitat for wildlife from the southern foothills to central Bhutan.

100. Long before it was established as a national park, Royal Manas was maintained as a wildlife preserve by the government since 1966. Later it was upgraded to a national park in 1993. The Royal Manas National Park has an area of 1,023 km^2 and covers parts of Sarpang (Taklai Gewog) and Zhemgang dzongkhags.

101. The Royal Manas National Park is the richest park along the subtropical ecosystems of the country with the highest area under broadleaf forest. Combined with the Jigme Singye Wangchuck National Park and India's Manas in the South, it creates a unique protected area complex across two countries. There are estimated 3,250 people residing inside the park.

102. **Phibsoo Wildlife Sanctuary.** This 278 km^2 wildlife sanctuary encompasses parts of Senge Gewog of Sarpang dzongkhag. It borders the Indian State of Assam to the south, and Tsirang dzongkhag to the north. It is currently managed by the Phibsoo range under Sarpang dzongkhag Forest Office. The Sanctuary is unique for its natural Sal (Shorea robusta) forest and for its spotted deer (axis axis). Other significant mammals species found here are tiger, Asian elephant and golden langur. The buffer of the Sanctuary is almost uninhabited. Since the sanctuary is yet to be operationalized, its exact boundary is yet to be determined.

Rare or Endangered Species

103. Some notable species found in the protected areas mentioned above are the tiger (panthera tigris), elephant (elephas maximus), Himalayan black bear (selenarctors thibetanus), sloth bear (Melursus ursi nus), leopard (panthera pardus), gaur (bos gaurus) and endemic species such as golden langur (presbytis geei) and spotted deer (axis axis).

104. Species such as the one-horned rhinocers (rhinocerors unicornis), hispid hare (caprolagus hispidus) and pygmy hog (Sus salvinus) are said to exist in Royal Manas, but have rarely been sighted. Other common species include barking deer (muntiacornis sumatraensis) Indian porcupine (hysterix indica) and goral (naemorhedus goral). In addition, there are a number of snake species.

Forest and Fauna

105. The dominant forest type in all eight dzongkhags is broadleaf, accounting for 30% to 95% of the forest areas. The second dominant category of forest is mixed conifer. The forests in the protected areas mainly comprise subtropical forests, warm broadleaved forest and cool broadleaved forests. Trees commonly found in the subtropical zone, which extends 200 m up

to 1,000 m, include bombax ceiba, ailanthus grandis, dillenia pentagyna, duabange grandiflora, schime wallichii, tetrameles nudiflora, mangifere sylvatica, terminalia myriocarpa, ostodes paniculata and species of musa, polyalthia, castanopsis, cinnamomum, fisus and grewia.

106. The warm broadleaved zone extends from the elevation of 1,000 m to 2,000 m and comprises such species as alnus nepalensis, macaranga spp. altinga excelsa, castanopsis indica, michelia excels, bombax spp., ficus spp., terminalia spp., acacaia., dalbergia., mussaendra roxburghii rhaphidophora species, maesa spp., albizzia spp., dichroa febrifuga and engellhardia spicata.

107. The cool broadleaved forest exists from 2,000 m to 4500 m, and comprises mainly betula alnodes, elastotema spp., symplocus spp., lindera pulcherrima, persea spp., exbuckllandia populnea, cantanopsis hystrix, lithocarpus elegans, and eurya spp.

Wildlife

108. A wide variety of fauna including the protected species listed in Table J-4 inhabit the forest areas. A list of avifauna found or expected to be found in the dzongkhags of the biogas pilot project is given in Table J-5. Table J-6 shows the list of protected species included in the Forest and Nature Conservation Act 1995. No endangered species of flora or fauna is anticipated at the villages where biogas plants are anticipated to be installed as these villages have already been affected by human activities. Therefore, no significant impact on flora, fauna or avifauna is expected from the project activities.

Table J-4: Endangered or Vulnerable Species Expected in Protected Areas

Common Name	Scientific Name	IUCN Red List Category	Bhutanes protection Category
Golden Langur	Presbytis geei	EN	Schedule I
Sloth Bear	Melursus ursinus	VU	Schedule I
Himalayan black Bear	Selenarctors thibetanus	VU	Schedule I
Clouded Leopard	Neofelis pardus	V	Schedule I
Common Leopard	Panthera pardus	LC	Schedule I
Tiger	Panthera tigris	EN	Schedule I
Asian Elephant	Elephas maximus	E	Schedule I
Leopard Cat	Prionailurus bengalensis	LC	Schedule I
Capped Langur	Trachypithecus pileatus	EN	Schedule I
Marbled Cat	Felis marmorata	VU	Schedule I
Wild Dog	Cuon alpines	EN	Schedule I
Gaur	Bos gaurus	V	Schedule I
Spotted Deer	Axis axis	EN	Schedule I
EN = Endangered, VU = Vulnerable, LR = Lower Risk, NT = Near threatened, LC = Least Concern,			

Table J-4: Endangered or Vulnerable Species Expected in Protected Areas			
Common Name	**Scientific Name**	**IUCN Red List Category**	**Bhutanes protection Category**
IUCN = International Union for Conservation of Nature.			

Table J-5: Avifauna of the Project Areas		
S. No.	**Common name**	**Scientific Name**
1	Ashy Drongo	Dicrurus leucophaeus
2	Ashy Woodswallow	Artamus fuscus
3	Asian barred Owlet	Glaucidium cuculodies
4	Asian Palm Swift	Cypsiurus balasiensis
5	Asian Paradise-flycatcher	Tersiphone paradisi
6	Barred Cuckoo Dove	Macropygia unchall
7	Bar-winged Flycatcher-Shrike	Hemipus picatus
8	Block Stork	Ciconia nigra
9	Black-backed forktail	Enicurus picatus
10	Black-crested Bulbul	Pycnonotus melanicterus
11	Black-throated Sunbird	Aethopyga saturate
12	Blue-throated Barbet	Megalaima asisatica
13	Blue-winged Minla	Minla cyanouroptera
14	Blyth’s Leaf Warbler	Phylloscopus reguloides
15	Bronzed Drongo	Dicrurus aeneus
16	Chestnut-bellied Nuthatch	Sitta castanea
17	Chestnut-headed Bee-eater	Merops leschhenaulti
18	Chestnut-tailed starling	Sturnus malabaricus
19	Collared Owlet	Glaucisium brodiei
20	Common Myna	Acridotheres tristis
21	Common Stonechat	Saxicola torquata
22	Common Tailobird	Orthotomus sutorius
23	Crow-billed drongo	Dicrurus annectans
24	Dollarbird	Eurystomus orientails
25	Drongo Cuckoo	Surniculus lugubris
26	Emerald Dove	Chalcophas indica
27	Eurasian Tree Sparrow	Passer montanus
28	Golden-fronted Leafbird	Chalophaps indica
29	Great Barbet	Megalamia virens
30	**Great Hornbill**	**Buceros bicornis***
31	Greater Neclaced Laughingthrush	Chrysocolaptes lucidus
32	Greater Racket-tailed Drongo	Garrulax pectoralis
33	Greater Yellownape	Dicrurus pectoralis
34	Grey Wagtail	Picus flavinucha
35	Grey Wagtail	Motacilla cinerea
36	Grey-Backed Shrike	Lanius tephronotus
37	Hill Myna	Gracula religiosa

Table J-5: Avifauna of the Project Areas		
S. No.	**Common name**	**Scientific Name**
38	House Crow	Corvus splendens
39	Indian Pond Heron	Ardeola grayii
40	Large Woodshrike	Tephrodornis gularis
41	Large-billed Crow	Corvus macrorhynchos
42	Lesser Racket-Tailed Drongo	Dicrurus remifer
43	Lesser Yellownape	Picus chlorophus
44	Long-tailed Broadbill	Pasarious dalhousiae
45	Long-tailed Shrike	Lanius schach
46	Mountain Imperial Pigeon	Ducula badia
47	Mountain Scops Owl	Otus spilocephalus
48	Orange-bellied Leafbird	Chloropsis hardwickii
49	Oriented Honey-buzzard	Pernis Ptilorhyncus
50	Oriental Magpie Robin	Cospsychus saularies
51	Oriented pied Hornbill	Anthraceros albirostris
52	Osprey	Pandion haliaetus
53	Pale-chinned Flycatcher	Cyornis poligenys
54	Pin-tailed Green Pingeon	Treron apicauda
55	Plain Flowerpecker	Dicaeum concolor
56	Red-headed Trogon	Harpactes erythrocephalus
57	Red-rumped Swallow	Hirundo daurica
58	Red-tailed Minla	Minla ignotincta
59	Red-vented Bulbul	Pycnonotus cafer
60	River Lapwing	Vanellus duvaucelii
61	Rifous Woodpecker	Celeus brachyurus
62	Rufous-bellied Niltava	Niltava sundara
63	Ruffous-necked Hornbill	Aceros nipalensis
64	Scaly Thrush	Zoothera dauma
65	Scarlet minivet	Pericrocotus flammeus
66	Slaty-blue Flycatcher	Ficedula tricolor
67	Small Niltava	Niltava macgrioriae
68	Snowy-browed Flycatcher	Ficedula hyperythra
69	Spangled Drongo	Dicrurus hattentottus
70	Spotted Dove	Streptoplia chinenesis
71	Streaked Spiderhunter	Arachnotherea magna
72	White Wagtail	Motacilla alba
73	White-rumped Shama	Copsychus malabaricus
74	White-throted Kingfisher	Halcyon smymensis
75	Wreathed Hornbill	Aceros undulates
76	Yellow-bellied Fantail	Rhipidura hypoxantha
*Near threatened species globally		

Table J-6: Species Listed in the Forest and Nature Conservation Act		
Common Name	**Scientific Name**	
Schedule 1A – Protected Wildlife		
Asian Elephant	Elephus maximus	
Clouded Leopard	Neofelis nebulosa	
Golden Langur	Presbytis geei	
Musk Deer	Moschus Chrysogaster	
Pangolin	Manis crassicaudata	
Pigmy Hog	Sus sylvanicus	
Snow Leopard	Panthera unica	
Takin	Budorcas taxicolor	
Tiger	Panthera tigris	
Wild Buffalo	Bubalus bubalis	
Golden Masheer	Tor tor	
Spotted Deer	Axis axis	
Gaur	Bos gaurus	
Leopard	Panthera pardus	
Leopard Cat	Felis bengalensis	
Himalayan Black Bear	Selenarctos thibetanus	
Red Panda	Ailurus fulgens	
Serow	Capricirnis sumatraensis	
Protected Birds		
Black-Necked Crane	Grus nigricollis	
Monal Pheasant	Lophophorus impejenus	
Peacock Pheasant	Polyplectron bicalcaratum	
Raven	Corvus corax	
Rufous-Necked Hornbill	Aceros nepalensis	
Schedule – IB : Protected Plant Species		
Local Name	**Common Name**	**Botanical Name**
Agar/ agaru	Eagle Wood	Aquilaria malaccensis
Yartsa-guenboop	Chinese Caterpillar	Cordyceps sinensis
Pang-gen metog	-	Gentiana creassuloides
-	Snow Down Lily	Llyodia yummanesis
Tsher-ngeon	Blue Poppy	Meconopisis grandis
Kirang-shing	Yew	Taxus baccata
Bhreeng-geeradza Ginseng	-	Panax pseudo-ginseng

5.3 Economic Development Resources

109. **Land Use, Industry and Agriculture.** The forest cover in the dzongkhags selected for biogas pilot project ranges from 53.6% (Pemagashtel) to 88.5 % (Mongar). The cultivable area is less than 15% in all the eight dzongkhags except Pemagashtel. The other land uses in the dzongkhags are under pastures, water bodies, rocky area and settlement. The area under

settlement is less than 0.12% in all the dzongkhags of biogas pilot project areas. This is due to the low population density of the country at 16 per square km. Due to the flat terrain, fertile sedimentary soil layers, and suitable climatic condition, most of the arable wetland is presently under rice cultivation in southern dzongkhags, namely Sarpang, Pemagashtel and Samdrupjongkhar. Due to its high production of rice, Sarpang is known as the "Rice Bowl of Bhutan."

110. Major crops produced in the project areas include maize, wheat, buckwheat, barley, mustard, finger millet and foxtail millet along with a wide variety of green vegetables. While orange is grown in almost all southern dzongkhags of the country, cardamom, areca nut, ginger, guava, lemon, banana and mango are also grown extensively. Mango is also grown in Samdrup Jongkhar.

111. Almost every household in all eight dzongkhags owns some livestock, mostly local breeds, to meet their need for milk, butter, cheese, meat and manure. The livestock also plays an important role in the rural areas by providing draught power in the absence of mechanized farming. Because of the livestock availability, the biogas pilot project is being proposed in these dzongkhags. For those villages near the towns, any surplus farm products are taken to towns for sale.

112. Most of the existing industrial establishments in Bhutan are small-scale or cottage industries. In the project areas there are industries in Samtse and Sarpang. There is good growth potential for industries in Gelephu.

113. **Administrative Infrastructure and Community Facilities.** All dzongkhag headquarters in the project area – Samdrup Jongkhar, Sarpang, Chukha, Damphu, Pemagashtel, Mongar and Trashigang – have dzongkhag administrative offices such as Forest Deaprtment, Revenue Department, courthouse, etc. These also have amenities such as banks, post offices and communication centers.

114. The numbers of educational facilities (schools) reported in Pemagashtel, Samdrup Jongkhar, Mongar, Samtse, Trashigang, and Tsirang are 16, 8, 38, 13, 52 and 6, respectively. Health facilities are available in all eight dzongkhags. These facilities include referral hospitals, basic health units (BHU), and outreach clinics (e.g. Mongar Dzongkhag has one referral hospital and 17 basic health units, Pemagashtel dzongkhag has 4 basic health units and 22 outreach clinics, Samdrup Jongkhar dzongkhag has 2 hospitals and 13 BHUs, Tsirang dzongkhag has one general hospital and 3 BHUs). Livestock Extension Center (LEC), Agriculture Extension Center (AEC), and Rural Water Supply Schemes (RWSS) also exist in each dzongkhag.

115. **Transportation.** Transportation facilities in the eight dzongkhags are through road and mule tracks. Remote locations at high elevations are connected through mule track. In the dzongkhags selected for biogas pilot project, there is no airport. There is no railroad in any of the dzongkhags either.

116. Sarpang has 6.8% of the total road network in the country, totaling 310.2 km. this network comprises of 123.4 km of national highway, 42.6 km feeder road, 50.9 km farm road and 93.3 km forest road (Teri 2005).

117. In Trashigang there are 93 km of feeder roads. Chukha dzongkhag is connected with the National Highway connecting Thimphu to Phuentsolling. Tsirang and Sarpang are connected by Wangduephodrang – Sarpang highway. Samdrup Jongkhar is connected by the Bumthang-Sarpang highway. Mongar dzongkhag has a total of 34 km of feeder roads.

118. **Electricity and Communication**. The households close to dzongkhag headquarters have been electrified. According to the information available on dzongkhag websites, the numbers of households electrified are 244 in Samdrup Jongkhar, 1,563 in Samtse, 741 in Mongar, 1,547 in Pemagashtel, 2,197 in Sarpang, 2,500 in Trashigang, 1,194 in Chukha, and 1,188 in Tsirang.

119. All dzongkhag headquarters are connected by line telephone. All dzongkhag towns have mobile connectivity.

120. As for telecommunication services, there are two telephone exchanges in Gelephu and Sarpang and a total of 733 km of telephone lines are installed (9th FYP). Post offices are located at all Gewog and dzongkhag headquarters.

121. **Tourism.** Before the 1970s only the Royal family had the authority to issue invitations to visit Bhutan, so almost all foreign visitors were Royal guests. The first time a large number of foreign visitors entered the kingdom was for the coronation of the fourth king in 1974, and this was followed soon after by the first paying tourists. Paro airport opened in 1983, and the newly-formed national airline, Durk Air, started operating flights to Kolkata. Tourism grew gradually, and in 1991 the industry was privatized, and numerous tourist agencies were established. Visitor numbers have continued to rise, particularly over the past few years, despite the requirement for all tourists to pay a non-refundable daily tariff of US $200 to the tour operator, for the cost of accommodation, food and internal travel. Tourism is now the third-largest provider of foreign exchange in Bhutan, earning US $18.5 million in 2005 with 13,600 visitors.

122. The majority of tourists visit the dzongkhags with tourist resources, such as Paro, Thimphu, Punuakha, Wangduephodrang and Bumthang, which account for over 77% of the total bed nights. The eight dzongkhags selected for biogas pilot project have little or no tourism.

5.4 Social and Cultural Resources

123. **Demography.** The population of Bhutan includes many ethnic groups such as the Sharchops in the east, Ngalongs in the west, Khengpas in the central region, nomads in the north and Lhotshampas in the south. Because of the mix of ethnicities, a wide variety of dialects are spoken, of which Dzongkha, Khengkha, Sharchop and various dialects of Nepali are

the most common. The majority of the population is Buddhist (around 70%) and the remainder is mainly Hindu, mostly in the southern areas.

124. The project areas have a sex (male/female) ratio of 1:1. In the project areas about 70% of the population is rural residents while 30% is urban dwellers. The average number of family members per household is 4.7. The employment rate is about 34%. Around 73% of the households own land, 57% own their home, 8% own their own business and 7% own a vehicle.

125. **History and Cultural**. Few tourists visit the remote villages, but this does not mean that they do not contain features of cultural significance. Most of the larger villages have at least one temple. There are smaller Buddhist shrines both inside and outside inhabited areas. There are also various places or objects that are of significance to the community, including particular trees, river and other locations. As biogas plants are to be built in the backyards of participating farmers, no historical or cultural monuments of heritage importance is expected from the proposed pilot project.

6. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATING MEASURES

126. This section summarizes the anticipated environmental impacts and mitigation measures during the construction and operations phases of the proposed pilot project. The proposed project has been classified as Safeguard Category B for environment and involuntary resettlement.

6.1 Environmentally Insignificant Issues

127. Environmentally insignificant issues for the proposed project are identified in the following paragraphs.

128. Although the dzongkhags where biogas plants are to be installed have forest areas and local wildlife, the proposed pilot project is not going to impinge on them as biogas plants will be located at residential/village areas away from the environmentally sensitive areas such as national parks, wildlife sanctuaries, natural reserves, and biological corridors. Thus, the environmentally insignificant issues to the proposed project include:

- Wildlife parks, biological corridors, national parks, and wildlife sanctuaries
- Historical and cultural heritage sites
- Special areas for protecting the biodiversity.

129. Based on the Rapid Environmental Assessment (REA) Checklist, the following impacts have been regarded as insignificant and reasons are given hereunder:

- Biodiversity, perennial water bodies
- Social impacts (no dislocation or resettlement would be required).

No problem with respect to migrant laborers is foreseen as only two or three local laborers would be employed for the construction of a typical biogas plant.

6.2 Environmentally Significant Issues/Valued Environmental Component

130. Based on the REA checklist, field visit and discussions with various government officials, the following issues have been identified as key valued environmental components:

Topography and soil
Local services
Water environment
Air quality
Noise level
Flora and fauna
Socio-economic conditions.

131. Since the identified impacts are associated with different phases of the project, they are discussed in the following subsections separately for the construction and operation phases of the project and appropriate mitigating measures are recommended.

6.3 Topography and Soil

Impacts

132. **Construction Phase.** The construction phase of the biogas pilot project will not have any significant impact on the topography of the area as biogas plant will be under ground. However, some minor changes in topography are expected due to the excavation of pits at residential areas and other construction works during the construction phase. Improper storage and disposal of construction spoils and unusable wastes can contaminate soil and land within the housing premises of farmer.

133. **Operations Phase.** During the operation phase of the proposed biogas pilot project, topography will not be affected; therefore, no impact is anticipated. However, organic manure will be generated in the form of a slurry that will be stored in the vicinity of the plant in an underground pit. Hence, no impact is anticipated on the soil of the area. There will be a positive impact on soil as farmers will apply this manure to their agriculture fields which will enhance crop productivity.

Mitigation Measures

134. **Construction Phase.** There will be careful handling and minimization of wastes as well as stacking of materials and equipment near the construction sites of the biogas plants. Proper housekeeping will be enforced during the construction phase to minimize impacts to the environment in the village. To minimize impacts to the environment, no heavy earth moving machines will be used.

135. **Operations Phase.** No impacts have been identified. On the contrary, there will be a positive impact on soil due to the generation of organic fertilizer, the bio-slurry byproduct of biogas plants.

6.4 Local Services- Environmental Impacts and Mitigation Measures

Impacts

136. **Construction Phase.** During this phase, there can be some minor impacts in the form of inconvenience to the villagers due to the transportation of construction materials. Proper scheduling of transport of construction materials will be able to reduce this inconvenience. The particular households planning to build a biogas plant will be aware of the schedule of construction and will adjust their routine for the short duration of construction (15-20 days). Other local services such as water supply and electricity supply are not anticipated to be impacted from the construction of biogas plants.

137. **Operations Phase.** During the operation phase there will be positive impact on rural services as farmers may use biogas for heating in addition to cooking. Therefore, a positive impact is anticipated on rural services during the operations phase.

Mitigation Measures

138. **Construction Phase.** The construction materials will be transported by forming a proper schedule in the area to avoid inconvenience to the village community.

139. **Operations Phase.** During the operation phase no adverse impacts have been identified; therefore, no mitigation measures are warranted.

6.5 Surface Water

Impacts

140. **Construction Phase.** No adverse impact on surface water quality is anticipated during the construction phase. The anticipated per-day consumption of surface water will not exceed 75-100 liters for the duration of 15-20 days. Any potential impacts during the construction phase can be kept under control by adopting proper mitigation measures included in the EMP.

141. **Operations Phase.** No impact on surface water resource is anticipated during the operation phase. No surface water consumption is anticipated for the operation of the biogas plants. The farmers will utilize the water for making the slurry of cattle dung for feeding the biogas plant from the allocated domestic supply.

Mitigation Measures

142. **Construction Phase.** During the construction the concerned farmer and construction crew will ensure that construction materials like earth, stone or appendages are disposed of in a way that does not block the flow of water of any water course (in the vicinity) and prevents temporary or permanent flooding of the site or any adjacent area. The water required for construction will be utilized from the allocated domestic supply.

143. **Operations Phase.** No impacts have been identified; therefore, no mitigation measures are warranted.

6.6 Groundwater

Impacts

144. **Construction Phase.** Groundwater will not be used for construction purposes and the problem of groundwater contamination is not anticipated during this phase.

145. **Operations Phase.** No impact is anticipated on the groundwater quality, as groundwater will not be utilized for the operation of biogas plants. The groundwater may become contaminated if there is leakage of biogas slurry from the biogas digesters.

Mitigation Measures

146. **Construction Phase.** No impacts have been identified during construction phase; therefore, no mitigation measures are warranted.

147. **Operations Phase.** No impacts have been identified during this phase; therefore, no mitigation measures are warranted. No impact on groundwater is anticipated as the PIU will ensure that the foundations of the biogas digesters will be made of impervious concrete to avoid any leakage.

6.7 Ambient Air Quality

Impacts

148. **Construction Phase.** Some emissions of dust are anticipated due to transportation and handling of construction materials. Some gaseous emissions may also be generated from vehicle exhausts during transport of construction materials to biogas plant sites. In case these are transported through animals such as mule or yak, there will be no generation of gaseous emissions. Pollutants of primary concern at this stage include suspended particulate matter (SPM), inhalable suspended particulate matter and gaseous emissions. The impacts during construction will be temporary and restricted to the close vicinity of the biogas plant construction site.

149. **Operations Phase.** No dust generation is likely during this phase. However, there may be accidental leakage from the biogas plant if the supply pipe is ruptured. In such case, no adverse impact on households is anticipated because methane gas being is than air and will disperse very quickly.

Mitigation Measures

150. **Construction Phase.** The ambient air quality impact identified during the construction phase is the generation of dust. This dust will be suppressed through spraying water at regular intervals at the biogas plant construction sites. The PIU will formulate a water spray schedule and instruct the construction crew and farmers to adhere to this schedule for the suppression of dust.

151. **Operations Phase.** Once in operation, the biogas plants will be inspected regularly by trained DOL extension officers and the quality control officer of the PIU for the performance and repairs of biogas plants. Hence, accidental leakages are not anticipated.

6.8 Noise

Impacts

152. **Construction Phase.** Some noise will be generated from the various construction activities including the operation of construction equipment and vehicles engaged in

transporting construction materials. The transport of construction materials will be required one time only; thus, no long lasting construction noise impacts are expected. The increase in ambient noise levels is expected to be marginal (between 5 to 10 % of existing ambient noise levels). Furthermore, these levels will be confined within the premises of farmers' houses and will be limited to the day time only. No construction works will be carried out at night.

153. **Operations Phase.** During the operations phase, no impact is anticipated on noise levels. Therefore, no mitigation measure is required.

Mitigation Measures

154. **Construction Phase.** In order to minimize the construction phase impacts, no construction activity will be carried out at night.

155. **Operations Phase.** No mitigation measures are warranted as no impacts have been identified during the operations phase.

6.9 Flora and Fauna

Impacts

156. **Construction Phase.** The construction activity will be carried out in the private habitation area; therefore, no adverse impact on fauna and flora is anticipated due to the proposed project. There will be no cutting of trees. There will be removal of grass and weeds from the biogas plant site in the premises of the participating farmers.

157. **Operations Phase.** During this phase, no impact on flora and fauna is anticipated as there will be no generation of pollutants from the operation of biogas plant. There will be a positive impact on flora as farmers' consumption of firewood for cooking will be reduced, resulting in less deforestation.

Mitigation Measures

158. **Construction Phase.** No mitigation measures are warranted as no adverse impacts have been identified during the construction phase.

159. **Operations Phase.** No mitigation measures are warranted as no impacts have been identified during the operations phase.

6.10 Debris/ Solid Waste

Impacts

160. **Construction Phase.** During the construction phase, surplus excavated earth will be generated by the creation of pits and leftover construction materials.

161. **Operations Phase.** During this phase, organic compost will be generated. It will be reusable as organic manure. The manure produced will need to be properly handled and utilized; otherwise, it will impact the aesthetics of the house.

162. The other impact identified is the content of manure. There is apprehension by the farmers that high nitrogen content in the manure may cause a nitrogen fixation problem in the agriculture fields.

Mitigation Measures

163. **Construction Phase.** The surplus earth, stone, grit, etc. will be utilized by the farmer for leveling vacant land in the vicinity of the house. In case it is not required for leveling, it will be disposed of in a nearby low-lying area.

164. **Operations Phase.** No mitigation measures are warranted as no impacts have been identified during the operations phase. The organic manure will be lifted at regular intervals for utilization in the farm, home garden, or community plantation. The generation of organic fertilizers (bio-slurry) from the pilot project will not be large enough to cause any problem of nitrogen fixation.

6.11 Local Water Supply

165. **Construction Phase.** The water demand for construction activity is not anticipated to interfere with the local water supply in light of the fact that it will be met by the domestic supply of the farmer.

166. **Operations Phase.** During this phase, there will be no interference with the local water supply as all water needs for operating the biogas plants will be met from the allocated supply of the farmers.

Mitigation Measures

167. **Construction Phase.** No mitigation measures are warranted as no adverse impacts have been identified during the construction phase.

168. **Operations Phase.** No mitigation measures are warranted as no impacts have been identified during the operations phase.

6.12 Utility Shifting Due to Installation of Biogas Plants

169. There will be no shifting of water supply lines, electric supply lines, or telephone and electricity poles due to the implementation of the proposed biogas pilot project.

6.13 Accidents and Risks

170. **Construction Phase.** The chances of accidents will exist in the initial construction phase when excavation is done for pits. Cattle and family members will be susceptible to falling in the pits if these are not properly fenced. No other risk is anticipated during the construction period.

171. **Operations Phase.** During the operations phase no accidents are anticipated except fire. It may occur if biogas leakage takes place and there is some ignition source close to this leakage.

Mitigation Measures for Accidents and Risks

172. **Construction Phase.** During the construction phase the excavated pit will be properly fenced. The PIU will provide necessary training to the construction crew to prevent construction accidents including accidental falling in the pits.

173. **Operations Phase.** The PIU will provide proper training to the farmers on the operation and maintenance of biogas plants. The pressures of the connecting pipe and other appurtenances will be regularly checked to avoid any leakage of the biogas.

6.14 Socio-economic Conditions

Impacts

174. **Construction Phase.** The proposed pilot project will not involve the dislocation or involuntary resettlement of people. The pilot project would result in overall improved environmental conditions of the farmers, thereby leading to a better quality of life. Positive impacts are anticipated in terms of employment opportunities because skilled, semi-skilled and unskilled personnel will get direct and indirect employment during the construction phase.

175. **Operations Phase.** In the operation phase no negative impacts are anticipated on socio-economic environment.

6.15 Human Health

Impacts

176. **Construction Phase.** During the construction phase, no long-term adverse impacts on health are anticipated as the dusts and emissions generated during construction are temporarily and confined to the immediate vicinity of the construction sites.

177. **Operations Phase.** During this phase, the chances of generating flies, insects and worms exist if cattle dung is stored in the open for a long time due to the non-operation of biogas plants.

Mitigation Measures

178. **Construction Phase.** Regular water spraying will be taken up to avoid any dust generation and indirect impacts on the health of construction crews.

179. **Operations Phase.** The chances of insects, worms and flies resulting from cattle dung not being used if the biogas plant is not working can be mitigated effectively. The proposed pilot project has included certain measures to minimize the potential down time of biogas plants, including 1) strict quality control of the plant construction to minimize the need for repair and maintenance and 2) provision of trained personnel to ensure timely repair and maintenance to minimize the down time of the plant. In case a plant is being repaired, farmers will be trained to handle cattle dung properly to avoid any formation of insects, worms or flies.

6.16 Positive Social and Environmental Benefits

180. The proposed biogas pilot project will have a host of environmental and social benefits, including:

- Reducing the consumption of fuelwood for cooking will reduce deforestation, greenhouse gas emissions, and health problems, especially for children and the elderly, caused by smokes from burning of fuelwood
- Cutting down consumption of LPG and kerosene for cooking will reduce greenhouse gas emissions and the nation's need for importing fossil fuels
- Diversifying energy resources and enhancing the nation's long-term energy security
- Promoting stall feeding of cattle to minimize forest grazing that contributes to environmental degradation

- Providing an innovative way of minimizing and managing cattle dung in an environmentally and economically beneficial manner
- Creating business opportunities for supply, installation, and services of biogas plants and spare parts
- Increasing farmers' ability to generate additional incomes from other activities by freeing their time from fuelwood collection, cleaning smoke blackened utensils and disposing of cattle dung
- Improving agriculture crop production through the use of organic manure from biogas plants and encouraging organic vegetable and fruit farming, and
- Serving as one of the complementary business opportunities for the country's dairy farmers cooperatives.

6.17 Conclusion

181. Based on the above assessment, the negative impacts due to the implementation of the proposed biogas pilot project are limited during the construction phase. These can be mitigated to acceptable levels through good construction practices.

182. The PIU will closely monitor the operation and performance of biogas plants and mitigate any unexpected environmental impacts.

7. ANALYSIS OF ALTERNATIVES

183. Three alternatives were considered for the biogas project: 1) the No Project Scenario (no biogas plant installation), b) Project Scenario, and c) Use of other form of energy such as electricity. These alternatives are analyzed below.

7.1 No Project Scenario

184. The population of Bhutan is rising and dependence on firewood for cooking and heating will continue to increase in the future under the No Project scenario. This will result in more deforestation and negative impacts on the ecology of the country. Farmers have to spend more time on collecting firewood from forests. The pace of development in the country will slow down as there will be no improvement in the quality of life. Greenhouse gas emissions will increase due to the burning of firewood and LPG. Burning firewood for cooking results in smoke inside the house and causes health problems to residents.

7.2 Project Scenario

185. The proposed project will provide a clean form of energy in the rural areas and cutting of forest trees will decrease. There will be positive impacts on the health of people. Farmers will save time on firewood collection, and can use this time for other income generating activities. This will lead the country to the path of growth. The organic manure available will increase crop productivity.

7.3 Other Forms of Energy (Electricity) Scenario

187. Electrical energy is also a clean form of energy, but in the winter months, there is a shortage of electricity supply due to the drastic reduction of hydroelectric power. At remote locations, electrification through on-grid connection is not possible due to technical and economic reasons.

7.4 Comparison of Alternatives

188. Table J-7 presents comparative analyses of the above three alternatives.

Table J-7: Comparison of Alternatives

Parameters	No Project Scenario	Project Scenario	Other Form of Energy Scenario (Electricity)
Economic cost	Financial cost incurred on firewood collection is minimal, time spent on collection is significant, and permits from the Forest Department become increasingly difficult to obtain	Considerable time will be saved on firewood collection The scheme will be financially attractive to participating farmers due to the subsidy and below-market loan provided	High cost- electricity supply for cooking and heating is beyond the affordability of farmers/rural population.
Developmental impacts & people's perceptions	Village/gewog considered underdeveloped	Community will be considered developed	Community will be considered developed.
Social benefit	Households will be exposed to smoke, dirt, and increasing distance/time spent on firewood collection	Clean and renewable energy The energy can be used for cooking and	Electric energy is also a clean form of energy Electricity supply at many remote isolated villages not

Table J-7: Comparison of Alternatives			
Parameters	**No Project Scenario**	**Project Scenario**	**Other Form of Energy Scenario (Electricity)**
		heating	possible due to difficulty in extending the grid
Environmental impacts	Yearly increase in firewood consumption and deforestation	No adverse environmental impacts Greenhouse gas emissions will be reduced Organic manure will increase crop productivity Reduced cutting of trees	Extending the grid will involve cutting of trees in the right of way of the grid. This will have negative impacts on forests.
Health	Negative impact on health due to smoke and dirt generation	Positive impact on health as biogas is a clean form of energy	Positive impacts on health

7.5 Conclusion

189. The installation of biogas plants to meet the cooking needs of rural farmers is the best alternative among the three alternatives considered. The biogas plants will help improve the quality of life of participating farmers. The successful implementation of the pilot project will lead to multiplication in other parts of country.

8. INFORMATION DISCLOSURE AND CONSULTATIONS

190. The successful implementation of the project requires the coordinated efforts of all stakeholders. Hence, consultations at different levels were conducted to inform and educate stakeholders about the proposed project both before and after the development decisions were made. Public consultation was useful for gathering environmental data, and understanding likely impacts and the community's needs and preferences.

191. Various alternatives could be evolved and sustainable mitigation measures could be formulated through consultations. This exercise assisted in the identification of the problems associated with the project as well as the needs of the population. This participatory

process helped improve people's perceptions and enabled their participation in the decision making process. The involvement of the various stakeholders ensured that the targeted population and other stakeholders are informed and consulted, and are allowed to participate at various stages of the project's development.

8.1 Objectives

192. The main objectives of the consultation process were to minimize negative perceptions and fears of the public about biogas plants and to maximize the benefits of the project. Other objectives of the consultation process were to:

- Promote public awareness about the proposed biogas project among targeted farmers who have more than 5 cattle
- Educate communities and individual farmers about the benefits of biogas to their life
- Solicit the views of communities and individual farmers residing in the targeted dzongkhags for biogas plant installations
- Gather inputs from the targeted population/individuals for improvements in project design and implementation procedures
- Stimulate community self evaluation and analysis
- Ensure a lessening of public resistance to change by providing them a platform in the decision making process.

8.2 Methodology Adopted for Public Consultations

Stages and Levels of Consultation

193. The consultations were conducted right from the start of the project to finalize its scope. For this project an inception workshop was organized by the consultants.

194. Public consultations were held at three levels:

- Local level: Chiwog (village) level/Geog (Block) level in the 8 targeted dzongkhags for the establishment of biogas plants
- Dzongkhag level: consultations involving Dzongdag, Revenue Department, Department of Livestock, local Forest Department, and dzongkhag environmental officers
- Institutional level: consultations with the National Environment Commission (NEC), DOL, Bhutan Power Corporation Ltd., Department of Energy, SNV Bhutan, the Ministry of Finance, etc.

Tools for Consultation

195. **Formal and Informal Discussion.** During visits to Gewogs in all eight dzongkhags, formal discussions were held with Dzongdags and informal discussion with locals and Gups (village heads).

196. A checklist of questions was kept ready and responses were elicited from participants. The focus group discussions were held in all eight dzongkhags.

197. **Stakeholders Consultative Workshop (Inception Workshop).** The institutional-level consultations were held with representatives of institutions having stakes in the project. These included the NEC, BPC, SNV Bhutan, Department of Energy (DOE), Department of Livestock, and the Ministry of Finance.

198. An inception workshop was organized on December 4, 2009 by the consultants and all institutional stakeholders were invited to comment and provide suggestions for the project.

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199. The consultations with institutional officials focused on the following issues.

- Project description: Need for renewable energy including biogas
- Advantages and low level of pollution (emissions/effluents/solid wastes)
- The extent and nature of social and environmental impacts and benefits
- People's participation in the planning, implementation, monitoring, and evaluation stages.

8.3 Location-Wise Summary of Consultations

200. The consultations at village levels and block levels were held in all eight dzongkhags. These are summarized in the following subsections.

Public Consultation at Chaskhar, Mongar, January 17, 2010

201. There were 15 participants present at the discussion along with the Gup of the Geog, the district DOL officer, Mr. Tashi and the Geog Livestock officer.

202. Participants had heard about biogas. Only 12 participants were invited, but 15 turned out because of their interest in biogas. Chaskhar has a very high rate of cattle holding and four or five participants stall feed their cattle. The average number of cattle holding is over 9 heads and firewood is a big problem for the community.

203. Households get firewood in truck loads delivered to their houses throughout the year. Only one house indicated possessing LPG gas. Household income is relatively high, indicating their ability to invest in the biogas plant using their own earnings. All the participants were eager to install a biogas plant. The livestock extension staff is also eager to give his best input into this project. Overall Chaskhar has a very high potential of taking up the biogas project. Some participants indicated they will be very interested in investing in a biogas plant if there is a subsidy from the government.

Public Consultation at Pam Trashigang, January 23, 2010

204. This meeting was held with the district DOL officer and the Geog livestock officer; nine people participated in all.

205. The average holding is between five and six cattle, most of which are stall fed. The community had been made aware of the potential biogas project from the government through a previous market survey done by the SVN. All but two of the participants had an interest in installing a biogas plant but were reluctant to do so because of the fear that the plant will not work. All of them wanted the other households to install plant firsts and if it works satisfactorily, then every household wants to install one. Only one household indicated a willingness to take the risk of installing the plant. Firewood is a severe problem for the community because of the increasing scarcity of this resource, coupled with labor shortage problems. Because of the firewood problem, all the households use LPG gas for cooking in addition to electricity.

Public Consultation at Gumang, Shumar Geog at Pemagatshel January 19, 2010

206. There were 14 participants present at the consultation. The assistant dzongkhag livestock officer was also present together with the Geog livestock officer.

207. The community of Gumang is relatively well to do and none of them had heard about the biogas plants. The cost of a cylinder of LPG gas is about Nu 500 including transportation. Firewood is scarce. Every participant present at the discussion wanted to install a biogas plant in his/her house. All of them are willing to invest the total amount, despite having to borrow from other sources. However, if there is a subsidy from the government for installing a biogas plant, then they would be more interested. The average holding of cattle among the participants is over 7 heads of cattle of hybrid variety. Participants were more concerned about the technical aspects of the biogas plant and they wanted to make sure that the plant will work satisfactorily after installation. Only two households have LPG and the rest gather firewood from the forest, spending a minimum of one hour each per day.

Public Consultation at Dewathang, Samdrup Jonkhar January 19, 2010

208. A total of 13 farmers attended the consultation workshop, but none of them had heard

about biogas before. The average holding of cattle is over 8 heads per household of a hybrid variety. The capital investment requirement for a biogas plant for the households was not a concern to most participants except for two households, as all of them had sufficient capital to invest. The technical performance of the plants was a concern voiced by all the participants.

209. Communities within the locality spend about two hours for a load of firewood and consume about two loads per day. Only one household uses LPG for cooking and the rest use firewood for all purposes.

210. The willingness to pay and affordability of a biogas plant was high; however, only two people were willing to invest immediately and the others indicated that they would invest only upon being assured that such a plant will work satisfactorily.

Public Consultation at Patabari, Sompangkha Geog at Sarpang Dzongkhag, January 20, 2010

211. There were 10 participants along with the dzongkhag livestock officer and the Geog livestock officer.

212. All the participants had heard about biogas plants and all of them had seen one across the border in the neighboring Indian village. Since what they saw across the border was working perfectly, all of them were motivated to invest in such a plant as they have enough cattle. Each household has both hybrid cattle as well as the local breed. They had even approached a technician across the border about installing such plants in Patabari through their own funding, but the technician did not come. With the new information on biogas plants they received during this consultation workshop, they were even more encouraged to install biogas plants through self-financing. Their only request now was not for funding but for a technician from the government to assist in the construction of the plants to ensure the plants will work properly. The materials available locally would be arranged by the participants. Immediately after this public consultation, the participants got together to prepare a written request to the dzongkhag livestock officer for a technician and wanted to start the construction immediately.

Public Consultation at Tsholingkhar Geog at Tsirang Dzongkhag, January 22, 2010

213. The workshop with 15 participants started with a briefing from the consultant, then a detailed explanation on how a biogas plant works, what are the prime requirements and costs, and what are the benefits. All the participants were interested in installing one in their houses. However, all of them would want to borrow on credit from the project as they cannot afford to invest the total amount of Nu 26,000 at one go through their own means. Participants were also concerned about the technician on the construction of the plant. Their request was again that the technician be provided by the project as the local technician would not be able to construct a plant that works properly.

Public Consultation at Lhakhu village under Guma Geog at Punakha Dzongkhag, January 24, 2010

214. Present at the meeting were 21 farmers. The consultation started with a briefing about the project followed by a detailed explanation on the functioning, costs and benefits of a biogas plant. The community in the past had a common biogas plant, but due to functionality problem, the plant had ceased operations. Over all, just one participant showed interest in installing a biogas plant at his house. Despite informing them about the loan provision by the government, the participants indicated they still were hesitant to invest. The rest of the participants indicated that the cost was a bit too much for them. They even debated on a common plant to serve for the community, but concluded that individual plants would be preferred over a common one.

Public Consultation at Tsakaling village under Yoeseltse Geog at Samtse Dzongkhag, January 28, 2010

215. 22 participants attended the consultation workshop along with the Gup of Yoeseltse and the assistant Geog livestock officer. The workshop started with an introduction to the biogas and a thorough explanation of the biogas plant. All the participants were new to biogas technology and had never heard about such a plant. They were interested in the functioning of such a technology and in installing a plant in the long run. All of them were interested in the funding modality as they mentioned that investment through their own savings would not be possible. The Gup, the Tshogpa and the assistant Geog livestock officer indicated that a model could first be installed in the Geog so that people from the other villages of the Geog and people from other Geogs could see such a plant functioning, which in turn would encourage them to invest. Firewood is a big problem for the communities of the Geog as it is getting scarcer, and the participants agreed that such a plant would save them time, money and labor from the collection of firewood from the forest.

Addressing Public Concerns in the Project Design

216. The project addressed the issues raised during the public consultations. The issues raised and responses provided are summarized in Table J-8.

Table J-8: Summary of Responses to the Issues or Concerns Raised in Public Consultations

Issue/Concern Raised	Responses/Comments Provided
In most local consultations, villagers stated that self-financing is not feasible	The project has been designed with a below-market loan and subsidy to help farmers overcome the financial barriers to investment in biogas plants
The villagers stated that local masons cannot construct biogas plants properly; thus, construction should be arranged by the government	The PIU will train on villagers the construction of biogas plants and issue certificate if they pass the tests. The quality of construction will be supervised and inspected by the PIU

Table J-8: Summary of Responses to the Issues or Concerns Raised in Public Consultations	
Issue/Concern Raised	**Responses/Comments Provided**
Collection of firewood is a problem because it involves time and energy and permits from the Forest Department are becoming more difficult to obtain	The biogas plants will substantially reduce the time and effort of farmers spent on firewood collection.
The biogas plants installed in the past did not function properly. Due to this, some participants were sceptical about biogas investment	The project will use biogas plant designs successfully tested in Bhutan and require the contractor to provide a two-year warranty. The PIU will also provide training to the owners on the operation and maintenance of biogas plants. Thus, the technical risks will be minimal.
A model biogas plant should be installed at the Gewog level for demonstration, then people will install them at the individual level	The project will be implemented in phase to ensure all the biogas plants in the initial year are successful and then gradually scale up in subsequent years
Common biogas plant should not be installed as it did not work properly at Punakha	The project aims to install individual household biogas plants, not common biogas plants

9. GRIEVANCE REDRESS MECHANISM

217. The biogas pilot project does not involve any acquisition of land, involuntary resettlement, or cutting of trees. Public complaints against the biogas plants are not anticipated as these will be private properties in the backyards of owners' house on registered land. The complaints related to the construction quality of biogas plants will be addressed by masons as the project will require all participating masons to provide to all plants a two-year warranty. The masons will be trained by the PIU on the construction of biogas plants. Other type of complaints by the owner will be addressed by the extension officer of DOL in the Gewog within one week. The extension officer will send information to the PIU after resolving the complaint. In case the complaint is not resolved by the extension officer, he or she will forward the complaint to the PIU at Thimphu. The PIU will address the complaint within two weeks. If there are any unforeseen complaints related to environment, these will be received by the PIU directly or through Gewog/dzongkhag extension officers. The quality control officer of the PIU will resolve the complaint within two weeks. The DOL will adopt an open door policy for suggestions of the public for the improvement of the performance of biogas plants and to make them popular among the masses. This will be done to achieve the ultimate goal of the pilot project: to scale up in subsequent phases to benefit more rural farmers.

10. INSTITUTIONAL REQUIREMENTS, ENVIRONMENTAL MANAGEMENT, AND MONITORING PLAN

10.1 Institutional Requirements

218. The biogas pilot project will be implemented and monitored by the Project Implementation Unit (PIU) of the Department of Livestock (the Ministry of Agriculture and Forests), which will be the Implementing Agency (IA).

219. The Department of Energy, Ministry of Economic Affairs will be the Executing Agency (EA). A high-level Biogas Advisory Committee consisting of the directors general of the DOE, DOL, Bhutan Development Finance Corporation, and SNV Bhutan will be established to provide policy guidance and oversight of the project's implementation.

220. The DOL will be responsible for ensuring compliance with the environmental requirements of the ADB as well as the National Environment Commission (NEC). All reporting requirements will be met by the PIU.

221. The Environmental Management Plan will be a part of training program to be given by the PIU to the masons and laborers to be employed for constructing the biogas plants across the country.

222. All the statutory clearances (at the national, dzongkhag and local levels) for the implementation of the biogas pilot project have been obtained in compliance with the national/dzongkhag laws and regulations and in accordance with ADB's environmental policy and guidelines.

10.2 Environment Monitoring Plan

223. To ensure the effective implementation of mitigation measures and the EMP during the construction and operations phases of the biogas pilot project, it is essential that the Environmental Monitoring Plan (Table J-8) be followed.

224. The PIU will have a quality control officer who will also monitor compliance with the EMP. The quality control officer will be a designated environmental officer in the PIU. The quality control officer will make monthly visits to the construction sites of biogas plants and will observe construction site works from the point of view of compliance with the EMP. On observing any deviation, he/she will explain it to the owner, construction crew and the concerned extension officers of the DOL to ensure EMP compliances.

225. During project operations, the DOL extension officers will make regular visits to the constructed biogas plants to monitor their performance and to educate the owners on the

maintenance of biogas plants. The quality control officer will also visit the biogas plant sites along with other PIU staff to see that there is no generation of flies, insects, worms and mosquitoes due to the improper handling of cattle slurry and digested sludge. The visits will be made quarterly.

10.3 Environmental Management Plan

226. The Environmental Management Plan includes measures to mitigate the negative impacts identified. For each mitigating measure to be taken, the EMP will include its location, timeframe, implementation and oversight/supervisory responsibilities. The identified impacts and suggested mitigation measures with institutional responsibilities are shown in Table J-9.

227. The cost of the EMP to mitigate the construction impacts identified is a part of the construction cost of the biogas plants. During the operations phase, the control of flies, worms, insects and mosquitoes is also a part of plant operation and maintenance cost. The time input of the quality control DOL extension officers is also built into the PIU operations cost. Hence, there are no exclusive EMP compliance costs; these have already been accounted for in other project implementation costs.

11. FINDINGS, RECOMMENDATIONS, AND CONCLUSION

11.1 Findings

228. The findings of the IEE are:

- The biogas pilot project is environment friendly as it will reduce deforestation resulting from reduced consumption of firewood for cooking. The quality of life of the rural population will improve as biogas is a clean, renewable fuel with no generation of smoke.
- No biogas plants will be built in habitations located within ecologically fragile areas such as national parks, wildlife parks, wildlife sanctuaries, and biological corridors.
- The environmental impacts identified are dust generation during construction and the generation of flies, insects and worms from cattle slurry when the biogas plants are not functioning during the operations phase.
- All impacts will be manageable to an acceptable level as there will be a Project Implementation Unit for the regular inspection and training of farmers and masons.
- The organic fertilizers available as a byproduct from the biogas plants as will increase crop productivity.
- Mitigation and monitoring measures with cost estimates have been developed

in the EMP. The EMP will be implemented by the PIU and masons, with oversight by the DOL, DOE, Biogas Advisory Committee, other government regulatory agencies, and ADB. Public consultations have been undertaken during project preparation. The PIU will follow an open door policy for receiving complaints, if any, from concerned farmers, and will conduct additional consultations as necessary during project implementation.

11.2 Recommendations

229. The IEE recommends that no biogas plants be built in habitations that are in the ecologically sensitive areas.

230. A maintenance and inspection schedule should be formulated by the PIU to minimize any potential down time of the biogas plants.

11.2 Conclusion

231. No biogas plants under the proposed biogas project will be built in environmentally sensitive areas. The project will not result in any long-term significant adverse impacts. Minimal negative environmental impacts are anticipated, mostly during construction. These can be mitigated successfully by implementing the EMP. The environmental and social benefits of the project and the government's objectives of renewable energy development outweigh the negative impacts.

232. Based on the environmental assessment activities conducted to date, the project is confirmed as environmental Category B and the IEE, including the EMP, is considered sufficient to meet the environmental assessment requirements of ADB and the RGOB. A full environmental impact assessment study is not required.

Table J-8: Environmental Monitoring Plan						
Environmental Component	**Project Stage**	**Parameter**	**Location**	**Duration / Frequency**	**Implementation**	**Supervision**
Air Quality	Construction	Dust generation at construction sites	Construction sites of biogas plants	Once during construction	Construction crew and owner	PIU
Noise	Construction	Noise generation due to construction	Construction sites of biogas plants	Once during construction	Construction crew and owner	PIU
Surface Water Quality	Construction	Construction waste disposal	Construction sites of biogas plants	Once during construction	Construction crew and owner	PIU
Hygiene at Biogas Plant and surroundings	Operation	Proper training on maintenance to avoid generation of insects, worms, flies, AND mosquitoes	Biogas plant sites	Quarterly	Quality control officer	PIU

Table J-9: Environmental Management Plan (EMP)						
Project Stage - Anticipated Environmental Issues and Impacts	**Proposed Mitigation Measures**	**Parameter to be Monitored**	**Measurement Frequency**	**Institutional Responsibility**		**Cost**
				Implementation	**Supervision**	
A. Design and Location						
Location of biogas plants	Plan all biogas plants in villages not in the ecologically sensitive areas such as national parks and biological corridors	Screening of applications from farmers	Prior to finalization of installation list	PIU	DOL	n/a
B. Construction Stage						
Disposal of waste materials and excess earth from construction sites	Construction wastes and excess earth will be collected and disposed in low lying areas; they will not be disposed of in water courses and connecting roads to villages Un-authorized construction materials will be stored by the owners indoors	Disposal of debris and spoils in accordance with statutory provisions and in an environmentally acceptable manner	Once after construction is over	Construction crew	PIU through Gewog DOL extension officers	Incidental to owner
Use of water for construction	The owner will make arrangement for water required for construction from his allocation of water supply and will not tap water from natural ground/surface water resources	Execution of conservation /mitigation measures	During construction period of about 20 days	Owners of biogas plants	PIU through DOL extension officers	N/A
Contamination of water resource from construction wastes	Measures will be taken to prevent the wastewater generated in construction from entering directly into rivers or other natural water resources	Execution of conservation /mitigation measures	During construction period of about 20 days	Construction crew and biogas plant owners	PIU through DOL extension officers	Incidental to work

Table J-9: Environmental Management Plan (EMP)						
Project Stage - Anticipated Environmental Issues and Impacts	**Proposed Mitigation Measures**	**Parameter to be Monitored**	**Measurement Frequency**	**Institutional Responsibility**		**Cost**
				Implementation	**Supervision**	
Dust generation	The construction crew and owner will take all necessary measures to suppress dust generation. Water sprays will be carried out at least twice a day, i.e., morning and afternoon	Execution of mitigation measures	During construction period of about 20 days	Construction crew and biogas plant owners	PIU through DOL extension officers	Incidental to work
	All stockpiles of construction materials at biogas plant sites shall be wetted regularly; otherwise they will be stored indoors by the owners					
Noise from construction sites	The construction works will be taken up in day time only	Mitigation measure	During construction period of about 20 days	Construction crew and owner	PIU through DOL extension officers	Incidental to work
B: Operation Phase						
Generation of flies, worms, insects and mosquitoes due to improper handling of dung slurry and digested sludge	The owners will be trained by the PIU to properly operate and maintain the biogas plant. Any malfunctioning not within the owner's control of owner will be rectified by the masons. The mason recruited by the PIU through extension officers will provide a two-year warranty.	Hygiene at biogas plant site	As per inspection plan of masons formulated by the PIU	DOL extension officers	PIU	Part of construct-ion warranty
	An inspection plan will be formulated for the mason by the PIU for effective maintenance and extension officers of Gewog will regularly visit biogas plants		Quarterly by mason and extension officers	DOL extension officers and mason	PIU	n/a

Table J-9: Environmental Management Plan (EMP)						
Project Stage - Anticipated Environmental Issues and Impacts	Proposed Mitigation Measures	Parameter to be Monitored	Measurement Frequency	Institutional Responsibility		Cost
				Implementation	Supervision	
	to educate the owners on effective operation. The quality control officer of the PIU will also visit the completed and operating biogas plants on a random basis each quarter to ascertain hygiene and any unforeseen environmental issues					
Possible leakage of biogas from pipes, and biogas plants	The owners of the biogas plant will be trained by the PIU for proper upkeep of connecting pipes and replacement of these at every five years. The farmers will be made aware of the possible occurrence of fire in case of leakage and necessary fire prevention measures to be taken in the event such an incident occurs.	Random visit to inspect any potential leakage of biogas	Quarterly	DOL Extension officers and mason	PIU	n/a
Odor problem from biogas plant	Effective maintenance to prevent biogas leakages from the digester, piping and stoves	Leakage of biogas	Every day during the operations phase	Owners of biogas plants	PIU	n/a

Appendix K

SUMMARY POVERTY REDUCTION AND SOCIAL STRATEGY, AND GENDER ACTION PLAN

SUMMARY POVERTY REDUCTION AND SOCIAL STRATEGY

Country/Project Title: Bhutan/Rural Renewable Energy Development Project			
Lending or Financing Modality:	Project Grant	Department/ Division:	South Asia / Energy Division
I. POVERTY ANALYSIS AND STRATEGY			
A. Link to the National Poverty Reduction Strategy and Country Partnership Strategy			
Despite Bhutan's rapid economic growth and significant development efforts in the past, about one-third of the country's population, mostly living in rural areas, continues to live below the poverty line. In addition to income poverty, notwithstanding the fact that the general quality of life in rural Bhutan has greatly improved, substantial qualitative and quantitative rural-urban differences remain in terms of access to social services, basic amenities and economic opportunities. As various surveys and studies reveal, there are large and extensive gaps between rural and urban areas in the country for various socio-economic indicators, including income levels. In this situation, connectivity improvements to rural areas (including its infrastructure development) have been one of the core strategies for the Royal Government of Bhutan. Based on the government's national poverty reduction strategy, the ADB's country partnership strategy has also focused on expanding rural electrification through the four loan and grant projects it has sponsored since 1995. Access to electricity and modern energy in rural areas is a key indicator of human development and economic growth since nearly 70% of the population of Bhutan lives in rural areas. Under the present 10th five-year plan, the government has committed to developing and promoting rural electrification by continuing to expand access to electricity for all the remaining un-electrified rural households in remote areas, either through on-grid connection or renewable sources of energy. The aim of the government is to provide electrification to 100% of the country's households by 2013. The Rural Renewable Energy Development Project will build on the achievements of previous			

Country/Project Title: Bhutan/Rural Renewable Energy Development Project	
ADB energy projects by supporting and facilitating the government's efforts in attaining its ambitious accelerated rural electrification target. The project has four components: 1) on-grid rural electrification, 2) off-grid rural electrification with solar home systems, 3) a wind power pilot, and 4) a biogas pilot.	
B. Poverty Analysis	**Targeting Classification:** General intervention

Key Issues:

In rural areas, only three of every five people belong to households that have access to electricity, with the percentage being much smaller among the poor (43%) than among the non-poor (67%), according to the RGOB's *Poverty Analysis Report 2007*. In unelectrified rural areas, their energy sources have been kerosene and fuelwood, which cause significant indoor pollution.

There has been no direct linkage between electrification and poverty reduction. This is because poverty reduction requires income generating activities that could be realized over time after improving many factors, including connectivity and access to modern clean energy, roads, and social services for health and education. However, access to electricity is one of the essential elements for income generation and subsequent poverty alleviation.

None of the project components will have adverse impacts on the rural communities in terms of poverty, as no loss of livelihood, employment or displacement will occur as a result of the project. During local level surveys and consultations, villagers requested the provision of financial assistance for rural electrification, off-grid solar home systems' operation and maintenance, and individual biogas plants. Public concerns of this nature have been satisfactorily addressed by the executing and implementing agencies. Grid extension has been supported by the Bhutan Power Corporation. Households targeted for solar home systems will receive solar sets free of cost. Repairs and maintenance will also be given free of cost, but in the case of spare parts replacement, the households will need to pay the equivalent of 10% of the cost of the spares to enhance their ownership and avoid misusing the systems. For the biogas plant installation, the government will provide a 45% subsidy to willing farmers. In addition to this, there will be a loan facility from the Bhutan Development Finance Corporation to the extent of 27.5% of the total cost after the balance of 27.5% is contributed by farmers as equity. Overall, the rural electrification project is expected to generate a number of positive impacts to beneficiary communities, all of which contribute to poverty alleviation and economic development. These include:

- access to reliable and cleaner forms of energy for lighting and cooking
- improved education, as better lighting will allow students to learn and study more productively for longer periods of time
- promotion of crafts work, weaving and other income-generating activities leading to enhanced incomes
- a cleaner living environment as smokes emitted from firewood cooking and kerosene lamps for lighting purposes are reduced
- promotion of recreational activities such as sports, reading, watching television, and

listening to the radio.

The beneficial impacts of rural electrification are even greater among smaller, more remote communities, where isolation presents an additional challenge to poverty alleviation and improving overall indicators of wellbeing and quality of life. The project will thus contribute significantly to poverty reduction and promote community integration through enhanced rural development. It will also ensure that coverage in terms of electricity provision is equitable where the poor, men, women, children and the elderly will have equal opportunities, thus supporting economic growth and contributing to social inclusion and long-term sustainable development.

II. SOCIAL ANALYSIS AND STRATEGY

A. Findings of the Social Analysis

The rural electrification project is an integral part of the poverty reduction strategy under the 10th Five-Year Plan (2008-2013). Households provided with reliable sources of electricity will see a positive impact on their economic and social activities. Electricity will indirectly help improve the quality of services provided in the basic health units, likely help increase student productivity, provide women with more time for productive activities, and replace the use of costly and more polluting sources of energy with cleaner and more reliable ones and reduce respiratory and eye ailments due to indoor smoke.

B. Consultation and Participation

The government and BPC rolled out public consultations to all the target districts to improve awareness of the project. Socio-economic baseline data were collected for 20% of the communities that will benefit across all four project components. Communities were consulted in an informed and participative manner and asked about their lighting preferences.

What level of C&P is envisaged during the project implementation and monitoring?

☒ Information sharing ☒ Consultation ☒ Collaborative decision making ☐ Empowerment

Was a C&P plan prepared? ☐ Yes ☒ No

No additional consultations will be required. The communities were informed of the rural electrification project and their eligibility for on-grid or renewable energy sources at an early stage of project appraisal. Consultation involved the participation of communities, the BPC, the Department of Energy, the district administration and the local governments.

C. Gender and Development

1. Key Issues. The rural electrification and alternative renewable energy development (e.g., biogas) is an equal opportunity activity although it is expected to primarily benefit women, children, and the elderly in rural environments. Electrification is expected to make positive interventions on gender development by facilitating and improving women's role and functions in the household, family and community. The most likely and obvious benefit to women is an improvement in their health resulting from access to better-quality general and maternal health

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care and a reduction in acute respiratory illnesses brought about from the inhalation of smoke emitted in the house from the current cooking, lighting and heating practices of burning firewood and using kerosene lamps. The project provides equal employment opportunities for women village technicians who support operation and maintenance work in remote on-grid and off-grid villages.			
2. Key Actions. Measures included in the design to promote gender equality and women's empowerment—access to and use of relevant services, resources, assets, or opportunities and participation in decision-making process: ☒ Gender plan ☐ Other actions/measures ☐ No action/measure			
III. SOCIAL SAFEGUARD ISSUES AND OTHER SOCIAL RISKS			
Issue	**Significant/Limited/ No Impact**	**Strategy to Address Issue**	**Plan or Other Measures Included in Design**
Involuntary resettlement	Land belonging to five households will be affected and they have opted for land for land compensation. One house that is located approximately 250 meters from the site will likely be disturbed by the noise generated from the wind turbines. Appropriate noise reduction barriers will be built once the noise level is measured and found to be unacceptable.	A resettlement plan has been prepared for the wind power component of the project. The plan will be implemented prior to the commencement of preparatory and construction works.	☒ Resettlement Plan ☐ Resettlement Framework ☐ Environment and Social Management System ☐ No Action
Indigenous peoples	There are no indigenous peoples in the direct or indirect area of influence of the project. As a result, no special provisions /mitigation measures for indigenous people's development plan is required.	No specific actions are foreseen. The project is categorized as C with respect to its impact on indigenous peoples.	☐ Indigenous Peoples Plan ☐ Indigenous Peoples Framework ☐ Environment and Social Management System ☒ No Action
Labor ☒ Employment opportunities ☐ Labor	Local communities will benefit from the availability of temporary employment	Labor will be managed in accordance with national labor	☐ Plan ☒ Other Action ☐ No Action

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retrenchment ☒ Core labor standards	opportunities generated during the implementation phase of the project.	laws and corporate policies and procedures of the implementing agency. Core labor standards are included in the assurances.	
Affordability	Affordability is not considered to be an issue as electricity is highly subsidized by the government, particularly for lifeline customers. Solar home systems will be provided to consumers free of cost. All the previous rural electrification projects indicated that there were no serious affordability issues involved.	For households that cannot afford house wiring for on-grid electrification, a free kit can be provided on request. BPC also can accept installment payments if it is proven to be reasonable.	☐ Action ☒ No Action
Other Risks and/or Vulnerabilities ☒HIV/AIDS ☐Human trafficking ☐Others (conflict, political instability, etc.)	The government, through the Ministry of Health, has been carrying out routine awareness campaigns and providing free health care facilities to minimize the spread of HIV/AIDS in the country. The government has extended the free health care package to all workers, both local and foreign. This campaign will cover this project.	No specific actions are required.	☐ Plan ☐ Other Action ☒ No Action
IV. MONITORING AND EVALUATION			
Are social indicators included in the design and monitoring framework to facilitate monitoring of social development activities and/or social impacts during project implementation? ☒ Yes ☐ No			

GENDER ACTION PLAN

1. The Rural Renewable Energy Development Project has been considered as a financing vehicle for integrating gender equality and women empowerment features. Women are expected to benefit substantially from electrification and the provision of other alternative renewable energy sources through improved health conditions and decreased workloads as they are the ones who dedicate the greatest amount of time to carrying out household-related activities and replacing fuelwood stocks, mainly for cooking purposes.

2. The project is expected to be implemented with the gender mainstreaming initiative of the “Improving Gender Inclusive Access to Clean and Renewable Energy in Bhutan, Nepal, and Sri Lanka” (the gender initiative) as an integral part of the overall project design.[52] Through this intervention in line with rural electrification, the gender mainstreaming outputs aim to provide rural women with sufficient skills training and empowerment for them to be able to sustain productive and income generating opportunities. The implementation of project interventions will be assigned by the gender initiative to local and international non-governmental organizations (NGO) and consultants. Energy-related operation and maintenance skills training and equipment and materials used for generating livelihood opportunities will be supported by the gender initiative.

3. The project aims to increase women’s access to affordable and reliable clean energy sources and technologies in selected project sites. The project will help achieve:

- Good practices in incorporating pro-poor and gender-related aspects in energy sector operations
- Effective interventions supporting gender-inclusive access to clean and renewable energy identified for replication. They include:

    a. Provision of clean and affordable energy that will improve indoor air quality by replacing more expensive and polluting fuelwood and kerosene.
    b. Reduction in time spent collecting fuelwood.
    c. Skills training and capacity building for expanding income generating and employment opportunities for women, in line with electrification.

4. Traditionally in Bhutan, which has a matrilineal society background, women enjoy equal status and opportunities with men. In fact, predominant inheritance laws are favorable to

[52] Although linked, the project and gender initiative are two separate interventions that are being considered independently for approval. These have separate project outputs and targets, and management and monitoring requirements that need to be met. The gender initiative will be responsible for managing and monitoring all gender-related activities approved under the initiative and reflected in the table included herein and integrated into the design and monitoring framework for the project.

women.[53] However, there are far fewer opportunities for women in rural areas in terms of skill training and employment. To promote gender empowering activities, a two-track approach from the project and the gender initiative will focus on the following outputs.

	Outputs	Activities & Targets	Timeline[54]	Responsibility
1	Gender review of energy sector programs and policies	A report summarizing and showcasing gaps, opportunities, best practices and lessons learned	Months 1–4	• Consultant • International NGO
On-grid rural electrification				
2	Women village technicians trained in grid system maintenance	60-day training of at least 120 village technicians, 40% of whom are women, under the Village Technicians Training Program of BPC.	Months 6–9	• BPC/DOE
Off-grid solar rural electrification				
3(a)	Women village technicians trained in off-grid solar home systems O&M	30-day training of at least 120 village technicians – target 40% women – will be trained under the BPC Village Technicians Training Program.[55]	Months 6–15	• BPC/DOE • Consultant
3(b)	User education program for safety and maintenance awareness, particularly for women	Audio-visual, user-education program, and user education manual (Dzongkha and English) distributed to 4,500 solar home system users in ensuring sustainable maintenance of solar systems at the house level.	Months 6-30	- DOE - Local NGO
Energy-based livelihood enhancement training				
4	Women's livelihoods enhanced through skills training	Skills training of 200 women from four dzongkhags (50 per districts) will be conducted for women-led micro-enterprises at project sites.[56]	Months 6-30	• Local NGO
Monitoring and Evaluation[57]				
5(a)	Gender mainstreamed PPMS system	A gender mainstreamed PPMS template will be developed for the project to monitor progress towards	Months 1-5 monthly monitoring field trips	• International NGO

[53] In rural areas, around 60% of property titles such as shares and building and business licenses are registered in favor of women.

[54] The gender initiative will recruit international gender and energy sector specialist and international and national NGOs.

[55] Trained technicians will be provided with a complete set of tools and safety equipment. The services of an international consultant will be retained to support the development of training manuals and materials.

[56] This will include training programs for improving productivity and marketing through income-generating activities using equipment and facilities (e.g., grinding mills), which will be available through electrification.

[57] The gender mainstreamed PPMS system that will be developed under the Grant, will be adapted to the loan GAP outcomes/targets/indicators, to include the project sites covered by rural electrification.

	Outputs	Activities & Targets	Timeline[54]	Responsibility
		gender equality outcomes, targets and indicators (bi-yearly reporting).		
5(b)	Pre/post implementation impact-based surveys and monitoring	Baseline data will be generated to enable impact-oriented surveys and monitoring of: 1) reduction in women's time spent on household chores, 2) increase in women's employment, and 3) improved women's health.	Month 1-36	
BPC = the Bhutan Power Corporation, DOE = Department of Energy, Ministry of Economic Affairs, NGO = non-governmental organization				

Appendix L
SOCIO-ECONOMIC SURVEY REPORT

1. EXECUTIVE SUMMARY

1. Located on the southern slopes of the eastern Himalayas, nestled between China to the north and India to the south, east and west, Bhutan covers an area of 38,394 square kilometers. Stretching for 300 km from east to west and 170 kilometers from north to south, the country is predominantly mountainous, with 72.5% of its area covered with forests, 10% with perennial snow and glaciers, about 8% under permanent cultivation and human habitation, 2% is under shifting cultivation, and 3.9% as meadows and pastures, while the rest of the land is either barren, rocky or scrubland.

2. Bhutan's rugged terrain combined with a small and scattered population makes it extremely difficult to deliver development programs and infrastructure to remote areas. About 70% of the Bhutanese people live in rural areas and depend for their livelihood on agriculture.

3. Remote areas in the Kingdom have lagged behind the rest of the country in terms of food security, income generation, employment opportunities, and school enrollment, primarily due to poor access. Every aspect of development depends on the ability to gain access to opportunities, goods, and services, electricity being one of them.

4. Rural electrification has been accorded the highest priority in the 10th Five-Year Plan (FYP) because of its role in improving the quality of life and stimulating socio-economic development in rural areas. The government's primary goal is to ensure balanced development throughout the country. The provision of rural electricity to all sections of the population will complement the efforts made by the government towards achieving balanced development.

5. A detailed socio-economic study was carried out. The methodologies used in this study comprised:

- literature/reports review
- secondary data
- key informants' interviews
- interviews and consultations with beneficiaries and stakeholders
- field surveys.

6. The study's principal objective was to assess the socio-economic situation of the sample households and study the baseline profiles of the population within the project areas. An important component of the study was to assess the ability and willingness of the potential

beneficiaries to pay for electricity installation at their homes, ability to pay the monthly electricity bill, and the ability to pay for meter security. For those targeted for solar home systems (SHS), this included their ability to pay for the solar sets, their repair and maintenance, and the deposit for solar battery replacement. For those who have the required number of cattle, their ability to invest in a biogas plant was assessed.

7. A total of 1,967 households were randomly selected for the socio-economic survey based on a 20% sampling of the remaining un-electrified households in 18 dzongkhags, These dzongkhags were Thimphu, Paro, Haa, Punakha, Wangdue Phodrang, Chukha, Samtse, Dagana, Tsirang, Sarpang, Zhemgang, Trongsa, Mongar, Lhuntse, Trashi Yangtse, Trashigang, Pemagatshel and Samdrup Jongkhar. The 1,967 households surveyed represented 10,702 persons.

8. The socio-economic findings reported in this study are based on the analysis of the survey data. The major findings of the survey are:

- Off-farm labor, livestock and farming the main economic activities of the surveyed households. Remittances and skilled labor such as carpentry, masonry and painting/carving also constitute other important sources of income.

- Access to basic services and amenities is poor among the communities surveyed.

- The main fuels used for cooking are: firewood (98.17%) and LPG (1.83%), Kerosene is also used as the secondary or tertiary source of energy for cooking (13.17% as secondary and 2.80% as tertiary).

- For lighting. 95.12% use kerosene as the primary source, while the rest use firewood, LPG candles and even pine shavings.

- On an average, households spend around 54 minutes every day on firewood collection and when converted into monetary terms, each household spends about Nu 22 per day on firewood.

- The average household landholding size is less than an acre for 16.42% of the surveyed population, 18% own between 2 to 3 acres, and 8.13% own more than 10 acres.

- 777 households reported having income from off-farm labor, while 698 households reported having income from livestock, and 631 households reported having income from agriculture. On the expenditure side, food is the main item the households spend money on followed by clothing and education.

- 43.32% of the households surveyed fall below the national poverty line of Nu 1,097 per person per month.

- Food security is a problem in the surveyed communities, where 24.86% of the surveyed population faces food shortages ranging from 1 month to all year round.

- 98.68% of the total surveyed households (1,967) reported preferring on-grid connection for electricity while 1.32% reported preferring SHS.

9. Of the 1,609 on-grid targeted households, 94.22% of those surveyed reported their ability and willingness to spend up to Nu 5,000 for internal house wiring, while 5.78% reported that they will not be able to spend as much. For the monthly electricity bills, 8.70% of the surveyed households reported being able to pay Nu 30 per month on electricity, while 10.19% reported being able to pay above Nu 200 per month. The rest of the households reported their ability to pay between Nu 30 and Nu 200 per month. Similarly, for the 358 households targeted for SHS, only 1% of the households reported their ability to pay the actual cost of the SHS, which was estimated at about Nu 26,000 to Nu 30,000. 9% of the households reported not being able to pay anything.

10. The surveyed households were well aware of the benefits of electrification. The benefits reported by the respondents included:

- Improved health
- Better quality of live
- Improvement in the educational performance of school children
- Increase in income
- Better communication
- Better social life
- Better wild life management
- More productive time.

11. This section also provides a broad framework and baseline socio-economic profiles for monitoring and evaluation of the project. The purpose of monitoring and evaluation is to assess the “before and after project scenario” in order to determine the actual benefits and impacts of the project against the anticipated benefits. The completed survey questionnaire forms and collected raw data were turned over to the DOE. Thus, future socio-economic surveys can draw samples from the same villages surveyed in this study to assess the long-term effects of the project on the above-mentioned social and economic indicators.

2. INTRODUCTION

12. Located on the southern slopes of the eastern Himalayas, nestled between China to the north and India to the south, east and west, Bhutan covers an area of 38,394 square kilometers.

Stretching for 300 kilometers from east to west and 170 kilometers from north to south, the country is predominantly a mountainous, with 72.5% of its area covered with forests, 10% with perennial snow and glaciers, about 8% under permanent cultivation and human habitation, 2% under shifting cultivation, and 3.9% as meadows and pastures, while the rest of the land is either barren, rocky or scrubland.

13. With elevations ranging from 160 meters in the south to over 7,000 meters above sea level in the north, the country is one of the most rugged mountain terrains in the world. The climate is as diverse as the altitude, with humid subtropical conditions in the south to temperate conditions in the mid altitudes, to cold in the north with almost year-round snow in the extreme north. Bhutan has four major river systems: the Drangme Chhu, the Punatsang Chhu, the Wang Chhu, and the Amo Chhu, all of which flow into the Indian plains. With diverse climatic conditions, difficult terrain, and sparsely inhabited villages, it is difficult to access some areas in providing communities with minimum basic infrastructure.

14. In 2007, Bhutan's population stood at 658,888, with 345,298 males and 313,590 females (52.4% male and 47.6% female). 43.5% of the population is below the age of 20 years, 34% is between 20 and 39 years, 15.5% between 40 and 60 years, and 7% over 60 years. 69% of the population lives in rural areas.

15. The country's health care system has drastically improved over the decades when it had a doctor to people ratio of 1:7,476 in 2001 compared to 1:4,312 in 2006. 90% of the country's population is covered by the health care system with 29 hospitals, 179 basic health units (BHU) 514 dispensaries and outreach clinics, 1 Indigenous hospital, 21 Indigenous dispensaries, and 150 doctors scattered all over the country. Life expectancy has increased from 47 years in the 1970s and 1980s to 68 years in the 2000s.

16. Similarly, Bhutan's education system has also expanded from just a monastic education system in the 1950s, with only 11 schools enrolling just 440 students in the late 1950s, to 1,158 schools and institutions catering to 169,776 students in 2007.

17. In 2004, agriculture contributed 24.7% to the total economy, as measured by the GDP. It was also the single-largest sector, providing livelihood to 79% of the population.[58] Over the years, the contribution of the agriculture sector to the GDP has been gradually decreasing and in 2006 it accounted for 21.4% of GDP. This decline results as the energy (hydropower) sector is rapidly increasing and is set to overtake agriculture as the largest contributor to GDP. Nonetheless, the agriculture sector was still the largest contributor to GDP in 2006. Agricultural practices have changed tremendously over the years. Until a decade ago, agriculture was practiced on a subsistence basis. Today, an increasing number of farms are mechanized with sizeable investment in machinery and other inputs that are subsidized by the government, leading to increases in exports of agricultural produce.

[58] *Statistical Yearbook of Bhutan 2007*, National Statistics Bureau.

18. Bhutan's industrial sector has played a relatively a small role in the economy, with industries like mining being relatively underdeveloped. On the other hand, the country has good deposits of minerals such as limestone, coal, graphite, gypsum, slate and dolomite. However, most mining activities are limited to relatively small operations, which are mainly involved in the mining of dolomite, gypsum, limestone, slate, coal, marble, quartzite and talc.

19. The country's manufacturing industry is dominated by a small number of major operators such as the Penden Cement Plant, the Bhutan Board Products Ltd., Bhutan Carbide and Chemicals Ltd., the Bhutan Ferro Alloys Ltd, and Bhutan Agro Industries Ltd. Of late a number of new industries have been established in Pasakha. In 2006 the number of industrial license holders was 985, by 2007 this figure increased to 1,113 with more than 90% being operated by the private sector. Most of the existing industrial establishments are small-scale or cottage industries.

20. Until 1961 Bhutan had no vehicular roads. In 1962 Bhutan saw its first motor vehicle. By 2007, the Kingdom had 4,544.73 km of vehicular roads around the country connecting 19 of the nation's 20 dzongkhags.

21. The country's major source of energy has traditionally been firewood, and it still represents the major source of energy consumption today, especially in the rural areas. With the commissioning of the first two units of the Chhukha Hydropower Projects in 1986, and the other two units in 1998, Bhutan increased its electricity generation substantially and became a significant exporter of energy to India. Hydropower projects like the Kurichhu and Basochhu generate substantial amounts of hydropower. The number of villages electrified increased from 1,210 in 2004/05 to 1,318 by December 2006.

22. Bhutan first opened its door to tourism in 1974 when only a handful of tourists visited the Kingdom. In 2001 Bhutan received a total of 6,393 tourists, within five years, by 2006, this number almost tripled with tourist arrivals shooting up to 17,342.

23. Bhutan's GDP in 2005 stood at Nu 33,390 million, by 2009 its GDP was Nu 58,547 million. Boosted by the earnings from Tala Hydropower Project Corporation, Bhutan's GDP grew at an average of 15% in the 2005 to 2009 period. Trade and other services sectors also grew at an average of 11.5% per year. Overall, electricity continues to dominate the country's exports, accounting for around half of its total exports over the 9th FYP period.

3. BACKGROUND

24. Although Bhutan has substantial sources of clean and renewable hydropower energy and is a major exporter of electricity to India, the distribution of electricity within the country is still limited. As of January 2008, about 48% of rural households in the country still do not have access to electricity.

25. Since the 6th FYP in 1988, 37,775 rural households have been electrified in the Kingdom (7,360 households in the 6th FYP, 5,473 in the 7th FYP, 9,164 in the 8th FYP, and 15,778 households in the 9th FYP). Of the 37,775 rural households electrified in this period, ADB has provided funds for the electrification of over 19,000. With an additional on-going rural electrification project, ADB will have electrified a total 30,000 households. With these achievements the percentage of rural households with access to electricity has gone up to 60% in 2008 from 40% in 2002.

26. The RGOB has set an ambitious target of achieving 100% rural electrification by 2013. To achieve this target, over 10,000 rural households will need to be electrified by 2013. ADB's country strategy program for Bhutan supports this objective and also seeks to assist Bhutan in reducing its incidence of poverty through improving the country's physical and social infrastructure.

27. This project is an integral part of the rural electrification (RE) program under the 10th FYP (2008-2013), and will help Bhutan electrify 5,075 households through on-grid connection and 1,896 households through off-grid solar home systems. In addition, the project will assist farmers in building 1,600 biogas plants, and the government in constructing a 360 kW wind power project, both on a pilot basis. The 5,075 households targeted for on-grid rural electrification are in 6 dzongkhags, in addition to approximately 3,200 households located in the 12 other dzongkhags to be financed by Japan International Coordination Agency, and over 200 households by the Austrian Development Agency.

28. This project is consistent with both the RGOB and ADB's policy of promoting equal regional distribution of economic and social development, reducing vulnerability to imported fuels, easing pressure on the Kingdom's forests, and reducing dependence on fuelwood through the expansion and distribution of rural electrification and biogas technology.

29. The provision of rural electrification and biogas technology are also expected to have an impact on poverty reduction through income-generating opportunities that electricity will provide and through improved health and education in the long run.

4. STUDY METHODOLOGY

30. A detailed social economic study was carried out in the period from December 2009 to February 2010. The methodology used is summarized in the following sections.

4.1 Literature Review

31. All literature and reports made available by the DOE and BPC were thoroughly reviewed. Further, literature and reports were obtained from various concerned agencies and

organizations such as Gross National Happiness Commission, National Statistics Bureau, and ADB. A number of documents on ADB guidelines were also studied by the consultant for incorporation into the report.

4.2 Secondary Data

32. Secondary data were collected from the SNV report on biogas and other relevant information from the DOE.

4.3 Key Informants Interviews

33. Extensive repeated discussions and consultations were held with officers and staff of concerned agencies and organizations.

4.4 Interview and Consultations with Beneficiaries

34. Interviews and consultations were held with beneficiaries in the field to increase awareness about the project, to share and disseminate information to people in the surveyed villages, to ensure that they have an understanding about the scope of the project and the need for their participation, and to identify perceived benefits and impacts of the project.

4.5 Questionnaires

35. Structured questionnaires were developed for the field surveys. Three sets of questionnaires were prepared: 1) one for the household-level, to be administered to the household heads in villages that are considered for on-grid electrification under this project, 2) another for the public consultation for those who would be solar home system recipients, and 3) the third one for households having five or more head of cattle for the biogas component. The household-level questionnaire was aimed at obtaining the response from the households on information related to baseline socio-economic conditions, evaluation of the likely impacts of electrification including the ability and willingness to pay for electrification, ability to capture the benefits of electrification, etc. The households targeted for SHS installation were assessed for their ability and willingness to pay for the solar set, replacement of batteries and maintenance of the sets. For the biogas component, information was gathered on willingness and interest in installing a biogas plant, and the ability and willingness to invest in a biogas plant.

4.6 Mobilizing and Training Field Enumerators on Conducting Socioeconomic Surveys

36. In total 22 enumerators and 2 supervisors were mobilized and a two-day training program was conducted for them. The enumerators were trained on conducting efficient and accurate socio-economic surveys and they were made to understand the reason and subject of the survey. They were familiarized with each component in the questionnaires and its administration, and how to elicit accurate and factual responses from the respondents. Extensive briefings on the survey formats and the process of questioning and filing of formats were imparted to the enumerators over the two-day training program.

4.7 Field Survey Operation

37. Prior to conducting the field surveys, letters were sent to the Administration Offices of all 18 targeted dzongkhags informing them about the impending survey and soliciting their cooperation and assistance.

38. A total of 22 enumerators were involved in the surveys, headed by 2 supervisors. The social consultant accompanied the enumerators to supervise and monitor the effectiveness and progress of the survey team, to validate that the questionnaires were filled in the manner required, to ensure that the survey schedule was followed, and to provide backstopping assistance to the enumerators.

4.8 Response Rates

39. Despite the best of efforts made, there were non-responses from a few households. The non-responses were mainly for the SHS, where few of the would-be recipients had migrated to warmer places during the cold season, when the survey was conducted. A household was considered to be non-responsive if there were no adults available in the household at the time of the survey or if the dwelling was found to be locked. To make up for the non-responses of the on-grid households, other houses in the village or alternate villages were selected. As a result, the overall response rate was about 90%.

4.9 Data Compilation, Tabulation and Analysis

40. The raw data obtained from the field were entered in a statistical package for social scientist software, compiled, and classified. The data were then checked and adjusted for inaccuracies and analyzed. Accordingly, data sets were prepared for project economic and social analysis. The raw survey data collected were turned over to the DOE.

4.10 Sampling Design

41. A 20% sample size of the total targeted households was selected for the survey. Of the total of 1,967 randomly selected households, 1,690 households in 18 dzongkhags were targeted for on-grid connection, and 358 households in 8 dzongkhags were targeted for SHS installations. A total of 18 targeted dzongkhags were covered in the survey: Thimphu, Paro, Haa, Punakha, Wangdue Phodrang, Trongsa, Zhemgang, Mongar, Lhuntse, Trashi Yangtse, Trashigang, Pema Gatshel, Samdrup Jongkhar, Sarpang, Tsirang, Dagana, Chukha and Samtse. The 1,967 households surveyed represented about 10,702 persons.

42. A very random sampling method was used to select the households. This was done prior to starting the survey and was left to the discretion of the enumerators. Although all of the villages to be covered under this project are very remote, the sampled households covered even the furthest and remotest villages.

43. Under each sample village, 20% of the households were surveyed as the number of households in the un-electrified villages was already known from desk reviews and through BPC. The lists of villages, Gewogs, and dzongkhags surveyed are provided in Annexure I and II.

5. SOCIOECONOMIC FINDINGS

5.1 Demographic Characteristics of the Households Surveyed

44. A total of 1,967 households in the 147 villages targeted for on-grid rural electrification and 38 villages targeted for SHS were surveyed. Of the total of 10,702 people surveyed, 5,312 were males and 5,390 were females (49.64% of the surveyed population was male while 50.36% was female). The average household has 5.4 persons. 5.15% of the surveyed population is below the age of 14 years of age and 8.47% is below the age of 24, while 35.12% over the age of 60. If we take the working age group as between 15 and 59 years of age, then the working population is 59.73%.

Table L-1: Distribution of Surveyed Population by Age Group and Gender

Age group	Frequency and Percentage					
	Male	%	Female	%	Both	%
0-4	91	1.71	85	1.58	176	1.64
5 to 9	112	2.11	108	2.00	220	2.06
10 to 14	70	1.32	85	1.58	155	1.45
15 to 19	71	1.34	88	1.63	159	1.49
20 to 24	93	1.75	103	1.91	196	1.83
25 to 29	163	3.07	181	3.36	344	3.21
30 to 34	211	3.97	240	4.45	451	4.21

Table L-1: Distribution of Surveyed Population by Age Group and Gender						
35 to 39	316	5.95	409	7.59	725	6.77
40 to 44	376	7.08	404	7.50	780	7.29
45 to 49	549	10.34	572	10.61	1121	10.47
50 to 54	651	12.26	672	12.47	1323	12.36
55 to 59	680	12.80	613	11.37	1293	12.08
60 to 64	579	10.90	588	10.91	1167	10.90
65 and above	1350	25.41	1242	23.04	2592	24.22
Total	**5312**	**100**	**5390**	**100**	**10702**	**9100**

45. Average household size ranges from one to fifteen. 8.44% of the households have two family members, 47.03% have from 3 to 5 members, 34.32% have 6 or 7 members, 9.61% of have between 9 to 12 members, and just 0.61% have 13 or more members.

Table L-2: Household Size		
Family size	**Frequency of Households**	**Percentage of Households**
2 members	166	8.44
3 to 5 members	925	47.03
6 to 8 members	675	34.32
9 to 12 members	189	9.61
13 to 15 members	12	0.61
Total	**1967**	**100.00**

5.2 Ethnicity

46. Ethno-linguistically, Bhutan is diverse even although its geographical area is small. This can be attributed to the country's pre-monarchial geo-political history prior to 1907 when Bhutan was not unified, where numerous feudal lords ruled and governed specific valleys. These fiefdoms adopted specific dialects and cultures, and followed different branches of Buddhism, which have evolved into the different ethno-linguistic groups found in Bhutan today. Now, at least 16 different dialects are spoken in Bhutan. These ethno-linguistic groups are differentiated by traditions and culture, and other socioeconomic patterns.

47. In the 18 dzongkhags surveyed, 7 distinct ethno-linguistic groups have been identified.

Table L-3: Ethno-linguistic Groups in the Surveyed Dzongkhags	
Dialect	**Dzongkhag**
Sharchopkha	Trashigang, Mongar, Pemagatshel, Samdrup Jongkhar
Lhotshampakha	Sarpang, Tsirang, Samtse, Chukha and Dagana
Khengkha	Zhemgang, Mongar
Kurtokha	Lhuentse

Table L-3: Ethno-linguistic Groups in the Surveyed Dzongkhags	
Yangtsepkha	Trashi Yangtse
Ngalong	Thimphu, Paro, Haa, Punakha and Wangdue
Trongsapakha	Trongsa

48. Today about 23 languages (including dialects) are spoken in Bhutan, and while Dzongkha is the national language, all other Bhutanese languages and dialects as well as English are widely spoken and accepted. Because linguistic areas may overlap, distinct dialects are now being diluted and mixed, leading to dialects and languages not being spoken uniformly throughout all gewogs in any particular dzongkhag.

5.3 Literacy and Education

49. Even in the Bhutanese rural context, a person is considered literate if he/she was reported as being able to read and write in at least one language, such as Dzongkha, English, of Lhotshampakha. The overall literacy rate of the population 6 years and older is estimated at 36.75%. About 39.97% of males are literate, while only 33.58% of females are literate.

50. In comparison to the national literacy rate, the literacy rate of the surveyed population is found to be much lower at 36.75%. This can be linked to such factors as remoteness and high incidence of poverty among the surveyed population.

51. About 60.03% of males surveyed have never attended formal school, while the figure for females stands at 66.42%. Table L-4 reflects the education status of the surveyed population by sex.

Table L-4: Education Status by Gender

Gender	Illiterate	%	NFE	%	PP	%	LSS	%	MSS	%	HSS	%	Bachelors	%	Monastic	%	Total	%
Male	3189	29.80	210	1.96	383	3.58	780	7.29	279	2.61	163	1.52	46	0.43	262	2.45	**5,312**	**49.64**
Female	3580	33.45	393	3.67	376	3.51	647	6.05	217	2.03	104	0.97	32	0.30	41	0.38	**5,390**	**50.36**
Total	**6,769**	**63.25**	**603**	**5.63**	**759**	**7.09**	**1,427**	**13.33**	**496**	**4.63**	**267**	**2.49**	**78**	**0.73**	**303**	**2.83**	**10,702**	**100**

52. The occupational profile of the surveyed population reveals that over 65% of the people are farmers, which would also include livestock rearing, followed by 21.95% as students. Children who are not of school going age constitute 7.04% of the population.

Table L-5: Occupational Profile		
Line of Occupation	**Frequency of Population**	**%**
Farmer	7,046	65.84
Civil Service	125	1.17
Armed Forces	17	0.16
Business	97	0.91
Dratshang	107	1.00
Pvt. Sector	111	1.04
Student	2,349	21.95
Minor	753	7.04
Unemployed	72	0.67
Others	25	0.23
Total	**10,702**	**100.00**

53. The total number of school going children in the surveyed area was 2,349, out of which 7 have dropped out and are no longer going to school.

Table L-6: School Going Children		
Children Attending School	**Number of Students**	**% of Retention and Drop Outs**
Total No. of students	2349	
Total students attending school	2342	99.70
Number of drop outs	7	0.3
Total	**4,698**	**100.00**

54. The educational facilities for the surveyed households are reflected in Table L-7. 77.22% of the surveyed households have access to either primary or community schools, while 11.74% have access to lower secondary-level school. Just over 11% have access to other educational facilities including NFE, which is supposed to cater to those who missed school. 50.73% of the students have to walk for less than an hour to get to school, while the rest have to walk for over an hour one way to get to school.

Table L-7: Education Facilities		
Level/types of School	**Frequency of Households**	**Percent**
Primary school	799	40.62
Community primary school	720	36.60
Lower secondary school	231	11.74
Middle secondary school	68	3.46
Higher secondary school	13	0.66
Monastic school	21	1.07
Nunnery	3	0.15

Table L-7: Education Facilities		
Level/types of School	**Frequency of Households**	**Percent**
Non-Formal Education	105	5.34
Others (Patshala)	7	0.36
Total	**1967**	**100**

5.4 Health

Health Conditions in the Past Year

55. Around 24.56% of the surveyed population reported that they had suffered from one of the illnesses or injuries listed in Table L-8 in the last year. Of these, more females reported suffering from illnesses or injuries than males.

Table L-8: Types of Diseases						
Types of Diseases	**Males**		**Females**		**Total**	**Percent**
	Frequency of HHs	**Percent**	**Frequency of HHs**	**Percent**		
Diarrhea	537	42.15	552	40.77	1089	41.44
Dysentery	44	3.45	49	3.62	93	3.54
Headache	339	26.61	371	27.40	710	27.02
Eye problems	22	1.73	35	2.58	57	2.17
Dental problems	25	1.96	22	1.62	47	1.79
Malaria	21	1.65	20	1.48	41	1.56
Respiratory Infections	9	0.71	12	0.89	21	0.80
Injuries	29	2.28	17	1.26	46	1.75
Others	248	19.47	276	20.38	524	19.94
Total	1274	100.00	1354	100.00	2628	100.00

56. 1,126 male family members lost some working days due to illnesses. 50 males lost over a month of working days to illnesses and 737 of them lost just up to five days. However, 148 male members despite being sick did not lose any working days.

Table L-9: Number of Working Days Lost by Male Household Members due to Illness						
Diseases Suffered from	**Number of Working Days Lost by Males HH Members Due To Illnesses**					**Total**
	Up to 5 days	**6 to 10 days**	**11 to 15 days**	**Up to a month**	**Over a month**	
Diarrhea	362	110	6	7	0	485
Dysentery	33	6	0	2	1	42
Headache	213	75	15	14	8	325
Eye problem	6	5	2	1	6	20
Dental Problem	10	9	3	1	1	24
Malaria	2	10	3	4	2	21

Table L-9: Number of Working Days Lost by Male Household Members due to Illness						
Respiratory Infection	2	1	1	0	3	7
Injuries	11	4	4	3	5	27
Others	98	33	9	11	24	175
Total	**737**	**253**	**43**	**43**	**50**	**1126**

57. Similarly, 1,205 female members lost some working days due to illnesses out of which 59 of them lost more than a month of working days and 777 lost just up to five working days. 149 of the females who suffered from illnesses did not lose any working days.

Table L-10: Number of Working Days Lost by Female Household Members due to Illness

Diseases Suffered from	Number of Working Days Lost by Females HH Members Due To Illnesses					
	Up to 5 days	6 to 10 days	11 to 15 days	Up to a month	Above a month	Total
Diarrhea	372	108	7	8	2	497
Dysentery	39	5	0	3	2	49
Headache	229	86	15	19	9	358
Eye problem	11	6	1	5	8	31
Dental Problem	6	7	3	4	2	22
Malaria	1	7	4	6	2	20
Respiratory Infection	3	1	1	1	5	11
Injuries	8	4	0	1	2	15
Others	108	36	13	18	27	202
Total	**777**	**260**	**44**	**65**	**59**	**1205**

58. 91.52% of the males who suffered from one of the illnesses consulted health service providers, while 8.48% did not consult any health service provider. With regard to females who suffered from illnesses, 91.73% consulted health service providers and 8.27% did not consult. The reason cited for not consulting a health service provider was that they either thought that the illness was not serious or that they did not have anybody to help back at home.

Table L-11: Consultations with Health Service Providers

	Male		Female	
	Frequency of HHs	Percent	Frequency of HHs	Percent
Consulted health service provider	1166	91.52	1242	91.73
Did not consult health service provider	108	8.48	112	8.27
Total	**1274**	**100**	**1354**	**100**

5.5 Housing, Household Amenities and Access to Services

59. Housing is considered as one of the basic necessities of life. Typically, rural households in Bhutan live in a house unlike in urban areas where the majority of the people live in apartments. 100% of the households surveyed own the house that they live in. The information collected on housing under this survey included the type of dwelling by the main construction materials used, size of housing determined by the number of rooms, the present occupancy status, and type of amenities available to the households.

60. The materials used for roofs, floors and walls by the surveyed households are presented in Table L-12. 67.92% of the households have their roof covered with corrugated galvanized iron (CGI), 10.88% with wood, 9.35% with bamboo, less than 1% with tiles and 10.98% with other materials (straw and banana leaves). For the construction of walls, people use a combination of materials like wood and bamboo or bamboo and straw.

Table L-12: Materials Used in House Construction

Materials Used	Roof		Floor		Walls	
	Frequency of HHs	Percent	Frequency of HHs	Percent	Frequency of HHs	Percent
Wood	214	10.88	1437	73.06	935	47.53
Concrete	0	0	13	0.66	180	9.15
Tiles	17	0.86	0	0	9	0.46
CGI	1336	67.92	0	0	9	0.46
Bamboo	184	9.35	30	1.53	455	23.13
Others	216	10.98	487	24.76	379	19.27
Total	**1967**	**100.00**	**1967**	**100.00**	**1967**	**100.00**

61. There is an immense effort from the government to provide each household with safe drinking water, motivate and assist in the construction of latrines and garbage pits, and provide services like livestock, agriculture and credit facilities. The finding from the survey reveals that 83.22% of the surveyed households have access to piped drinking water, 92.88% have some sort of latrine, 80.02% have some sort of garbage pit, and 59.13% reported having access to agriculture services and 59.48% to livestock services, while only 18.40% reported having access to formal credit facilities.

Table L-13: Common Facilities

Facilities	Frequency	Percent
Piped water	1637	83.22
Latrine	1827	92.88
Garbage pit	1574	80.02
Agriculture services	1163	59.13
Livestock services	1170	59.48

Table L-13: Common Facilities		
Formal credit facilities	362	18.40

62. Of the 330 households that lack piped water, 13.03% fetch water from rivers, 15.45% collect from ponds, 23.33% collect from springs, 20.61% fetch from streams, and 27.58% collect from either swamps or collection points in marshy areas.

Table L-14: Source of Drinking Water

Source of Drinking water	**Frequency**	**Percent**	**Percentage of Total**
River	43	13.03	2.19
Pond	51	15.45	2.59
Spring	77	23.33	3.91
Stream	68	20.61	3.46
Others	91	27.58	4.63
Total	330	**100**	16.78
Piped water	1637		83.22
Total	**1967**		**100**

63. Of those who have no piped water and have to fetch drinking water from other sources, 56.97% take less than 15 minutes one way, 22.73% take between 15 minutes to half an hour, and 20.30% take more than half an hour.

Table L-15: Time Spent on Fetching Drinking Water

Time Taken for Fetching Water	**Frequency**	**Percent**	**Percent of Total**
Less than 15 minutes	188	56.97	9.56
16 minutes to 30 minutes	75	22.73	3.81
Over 30 minutes	67	20.30	3.20
Total	**330**	**100.00**	**16.78**
Piped water	1637		83.22
Total	**1967**		**100**

64. Respondents were asked about the number of rooms their dwellings had (including bathrooms/toilets and kitchens). The average number of rooms of the households surveyed is over three rooms per household. Generally the data showed that households with higher levels of income have bigger houses with more rooms. Table L-16 shows that 9.96% of the surveyed households occupy houses with a single room, 31.06% with 2 rooms and just over 18% with 5 or more rooms.

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Table L-16: Size of Household and Housing Density

Number of Rooms in the House	**Frequency of HHs**	**Percentage**
1 room	196	9.96
2 rooms	611	31.06
3 rooms	453	23.03

Table L-16: Size of Household and Housing Density		
4 rooms	352	17.90
5 rooms	163	8.29
More than 5 rooms	192	9.76
Total	**1967**	**100.00**

65. Similarly, the number of family members living in those houses was also assessed and is presented in Table L-17. The data reveal that there are 34 households with 10 family members living in houses with a single room, 134 households in houses with two rooms, and only 63 households living with the same number of family members but living in houses with six rooms.

Table L-17: Family Size versus the Number of Rooms

No. of rooms	1 to 3 members	4 to 6 members	7 to 10 members	11 to 15 members	Total
1 room	46	116	34	0	196
2 rooms	147	321	134	9	611
3 rooms	96	235	112	10	453
4 rooms	62	161	116	13	352
5 rooms	32	69	53	9	163
6 rooms	29	83	63	17	192
Total	**412**	**985**	**512**	**58**	**1967**

5.6 Ownership of Assets

66. The survey also collected information on the ownership of assets such as land, cattle and other moveable assets. Assets like land and cattle are almost universally owned in rural Bhutan, although the holding may be small. However, cattle holding in the surveyed areas was just 85.87%, while land was 100%. Other assets varied from community to community. Assets like farm machinery, vehicles, TV, phone and mobile phones were also found among the communities, although in lesser numbers.

Table L-18: Assets Ownership

Asset Ownership	Frequency of HHs	Percentage
Land	1967	100
Cattle	1689	85.87
Poultry	1233	62.68
Equine	771	39.20
Farm machinery	143	7.27
Vehicle/2-wheelers	32	1.63
LPG	234	11.90
TV	93	4.73
Radio	1112	56.53
Phone	99	5.03
Mobile phones	1014	51.55

67. The land ownership data show that 18% of the surveyed households own between 2 to 3 acres of land of all categories (dry land, wetland, orchard, etc.), 16.42% of the households own 1 acre or less, while only 8.13% own over 10 acres.

Table L-19: Land Ownership

Land Ownership	Frequency of HHs	Percentage
1 acre	323	16.42
1 to 2 acres	321	16.32
2 to 3 acres	354	18.00
3 to 4 acres	201	10.22
4 to 5 acres	298	15.15
5 to 10 acres	310	15.76
Above 10 acres	160	8.13
Total	**1967**	**100.00**

68. 4.08% of the surveyed households did not own any cattle, while 40.82% own more than 5 head of cattle. Those owning more than 5 head were briefed and asked questions on biogas.

Table L-20: Ownership of Cattle

Cattle Ownership	Frequency of HHs	Percentage
No cattle	277	14.08
1 to 4 heads	886	45.05
5 heads and above	803	40.82
Total	**1967**	**100**

5.7 Major Crops Grown by the Surveyed Households

69. Rice is the dominant crop grown by the surveyed communities, followed by maize. Fewer households grow millet, wheat and potato as these crops are grown at relatively higher altitudes.

Table L-21: Major Crops Grown by the Surveyed Households

Main Crops Grown by HHs	No. of Households	Percent
Rice	1029	52.31
Maize	849	43.16
Barley	50	2.54
Millet	9	0.46
Others (wheat, potato)	30	1.53

70. 88.92% of the households need to guard their crops from wild animals and 11.08% do not. This could be one of the reasons leading to food shortages for the households. Of the households needing to guard crops from wild animals, 6.23% of women have to guard and 53.17% of both the males and females guard. The duration of time for guarding crops varies among communities and the types of crops grown. Generally, 45.05% of those who need to guard crops from wild animals do so for three months, 31.50% guard for more than three months and only 4.06% guard for a month. 87.14% of those who need to guard their crops believe that electricity would help communities in protecting crops from wild animals by either setting up electric traps or devising sirens. 94.98% have the feeling that electricity itself will scare away wild animals.

Table L-22: Guarding Crops from Wild Animals		
Crop guarding	**No. of Households**	**Percent**
Need to guard crops from wild animals	1749	88.92
No need to guard crops from wild animals	218	11.08
Total	**1967**	**100**

5.8 Household Borrowings

71. Households with small incomes, which lead to less or no savings, had to resort to borrowing money from the formal credit facilities available to the communities or other means. While just 74 households had loaned out money, 291 households had to resort to borrowing from others to fulfill their needs. Among those who borrowed money from others, 40.21% borrowed more than Nu 20,000 while only 6.87% borrowed Nu 1,000 or less.

Table L-23: Money Borrowed		
Amount of Loan Borrowed	**Frequency of HHs**	**Percent**
Up to Nu 1,000	20	6.87
Nu 1,001 to Nu10,000	108	37.11
Nu 10,001 to Nu 20,000	46	15.81
Above Nu 20,000	117	40.21
Total	**291**	**100.00**

72. The major source of borrowing is BDFC whose mandate is in providing financial assistance to rural communities. Borrowing from informal sources such as money lenders, friends, neighbors or relatives is also an important source. 69 households have borrowed money from more than one source.

Table L-24: Sources for Borrowing Money

Sources of Money Borrowed	Frequency of HHs
BDFC	152
BOB	14
BNB	6
RICB	0
Money lenders	8
Friends	39
Neighbors	91
Relatives	50

73. The reasons for borrowing money are various. 109 households mentioned that they borrowed money was for business and 77 mentioned that it was for house construction or renovation. 53 households mentioned that the reason for borrowing was for purchasing food.

Table L-25: Reasons for Borrowing

Reasons	Frequency of HHs
House construction/renovation	77
Purchase of land	5
Purchase of cattle	18
Purchase of food	53
Education	35
Medical treatment	12
Others (business)	109

74. The survey respondents were asked about how household members commute to the nearest service centers and how long it took for them to get there. Data obtained from the survey reveal that all households travel by foot to the nearest service centers. In some areas it takes over two days of walking to reach specific centers. This indicates that in rural areas service centers are not easily accessible. Information was also gathered on how long it took by vehicle, as most of the communities do have road connectivity.

Table L-26: Access to Services by Time Taken To Reach the Nearest Service Centers on Foot

Facilities	Time Taken on Foot																	
	Up to 30 minutes		30 minutes to 1 hour		1 hour to 1 and half hours		11/2 hrs to 2 hrs		2 to 3 hrs		3 to 5 hrs		Over 5 hrs		No facility		Total	
	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%

Table L-26: Access to Services by Time Taken To Reach the Nearest Service Centers on Foot

School	671	34.11	327	16.62	165	8.39	262	13.32	275	13.98	143	7.27	124	6.30			1967	100
BHU	471	23.95	214	10.88	141	7.17	221	11.24	376	19.12	263	13.37	281	14.29			1967	100
ORC	633	32.18	205	10.42	77	3.91	156	7.93	163	8.29	104	5.29	121	6.15	508	25.83	1967	100
Traditional healer	602	30.60	126	6.41	17	0.86	56	2.85	66	3.36	25	1.27	58	2.95	1017	51.70	1967	100
RNR center	381	19.37	196	9.96	129	6.56	219	11.13	400	20.34	293	14.90	349	17.74			1967	100
Gup's office	367	18.66	175	8.90	123	6.25	207	10.52	393	19.98	319	16.22	383	19.47			1967	100
Market	133	6.76	112	5.69	53	2.69	156	7.93	220	11.18	241	12.25	1052	53.48			1967	100
Road head	276	14.03	123	6.25	51	2.59	160	8.13	165	8.39	262	13.32	930	47.28			1967	100
dzongkhag head quarter	12	0.61	17	0.86	17	0.86	73	3.71	112	5.69	162	8.24	1574	80.02			1967	100
Village temple	1028	52.26	333	16.93	106	5.39	181	9.20	133	6.76	86	4.37	88	4.47	12	0.61	1967	100

Table L-27: Access to Services by Time Taken To Reach the Nearest Service Centers by Car

Facilities	Distance by car															
	Up to 30 minutes		30 minutes to 1 hour		1 hour to 2 hours		2 to 3 hrs		3 to 5 hrs		Over 5 hrs		No facility		Total	
	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%	No. of HHs	%
School	248	12.61	66	3.36	15	0.8	0						1638	83.27	1967	100
BHU	240	12.20	71	3.61	47	2.4	0						1609	81.80	1967	100
ORC	5	0.25	11	0.56	1	0.1	0						1950	99.14	1967	100
Traditional healer	29	1.47	1	0.05	2	0.1	0		1	0.05	15	0.76	1919	97.56	1967	100
RNR center	160	8.13	48	2.44	30	1.5	17	0.86			5	0.25	1707	86.78	1967	100
Gup's office	184	9.35	96	4.88	62	3.2	38	1.93	7	0.36	8	0.41	1572	79.92	1967	100
Market	174	8.85	122	6.20	129	6.6	47	2.39	17	0.86	53	2.69	1425	72.45	1967	100
dzongkhag head quarter	87	4.42	213	10.83	446	23	353	17.95	399	20.28	469	23.84			1967	100
Village temple	149	7.57	12	0.61	3	0.2	2	0.10	1	0.05	6	0.31	1794	91.20	1967	100

5.9 Sources of Energy

75. Firewood is the main source of energy or all the households surveyed. 100% of the households use firewood for cooking either as a primary source or secondary source, although 36 households (1.83%) indicated that they use LPG together with firewood.

Table L-28: Sources of Energy for Cooking						
Sources of Energy Used for Cooking	**Primary Source**	**Percent**	**Secondary Source**	**Percent**	**Tertiary Source**	**Percent**
Firewood	1931	98.17	32	1.63	0	0
LPG	36	1.83	185	9.41	0	0
Kerosene	0	0.00	259	13.17	55	2.80
Total	**1967**	**100**	**476**	**24.21**	**55**	**2.80**

76. 0.66% of the households reported using more than 5 backloads of firewood in a day. These were households with more family members and also these households had more cattle, which were stall fed. 53.18% of the households reported using 1 backload of firewood per day. However on an average households use 1.5 backloads of firewood per day. This indicates that dependence on firewood in the rural areas is very high, where in most cases household members themselves collect firewood. On an average, each household spends 54 minutes per day on collecting firewood. It is only the wealthier households where that deploy others for firewood collection. 81 households indicated buying firewood.

Table L-29: Quantity of Firewood Used Daily by Households		
Number of Backloads	**Frequency of HHs**	**Percentage**
1 back load	1046	53.18
2 backload	655	33.30
3 backloads	162	8.24
4 backloads	47	2.39
5 back loads	44	2.24
More than 5 backloads	13	0.66
Total	**1967**	**100.00**
1 backload = approximately 17 kg		

77. As reported above, only 4.12% of the surveyed households purchase firewood, while the rest of the households collect from the forest.

Table L-30: Households Purchasing Firewood		
Purchase of Firewood	**Frequency of HHs**	**Percentage of Total**
Purchased firewood	81	4.12
Did not purchase firewood	1886	95.88
Total	**1967**	**100**

78. Households that purchased firewood spent a maximum of Nu 5,000 in a year; 62.96% of the households spent less than Nu 100.

Table L-31: Expense on Firewood		
Money Spent in a Month on Purchase of Firewood	**Frequency of HHs**	**Percentage of Those Who Bought Firewood**
Less than Nu 100	51	62.96
Nu 101 to Nu 500	22	27.16
Nu 501 to Nu 1,000	5	6.17
Nu 1,001 to Nu 5,000	3	3.70
Total	**81**	**100**

79. 65.23% of the surveyed households pay some amount for firewood royalty while the remaining 34.77% did not pay any royalty. Royalty is paid to the forestry department in order to get a permit to cut down trees for firewood; the charges are very minimal.

Table L-32: Payment of Firewood Royalty		
Payment of Royalty for Firewood	**Frequency of HHs**	**Percentage of Total**
Paid for firewood royalty	1283	65.23
Did not pay for firewood royalty	684	34.77
Total	**1967**	**100**

80. 59.31% of the households paid less than Nu 50 as a royalty, while 0.78% paid above Nu 200. An attempt was made during the survey to monetize the cost of firewood where the time factor was taken into account and calculated on the daily wage rate. It worked out to be Nu 22.50 per household per day, on average.

Table L-33: Amount Paid for Royalty		
Amount Paid for Firewood Royalty	**Frequency of HHs**	**Percentage of Total that Paid a Royalty**
Less than Nu 50	761	59.31
Nu 51 to Nu 100	88	6.86
Nu 101 to Nu 150	305	23.77
Nu 151 to Nu 200	91	7.09
Above Nu 200	10	0.78
Don't know	28	2.18
Total	**1283**	**100.00**

81. Table L-34 gives a picture of what sources of energy households use for lighting their homes. The primary source of lighting is kerosene, which is used by 93.95% of the households. It is also interesting to note that households resort to firewood for lighting either as a secondary or tertiary source. Households also use pine shavings for lighting their homes. The “others” category includes generators and solar.

Table L-34: Sources of Energy for House Lighting		
Sources of Energy for House Lighting	**Frequency of HHs**	**Percent**
Firewood	480	24.40
LPG	22	1.12
Pressurized kerosene lamp	23	1.17
Ordinary kerosene lamp	1848	93.95
Batteries	142	7.22
Candles	124	6.30
Pine shavings	151	7.68
Others	356	18.10

82. 11.03% of the households use LPG at one time or the other for cooking. Of these, 12.90% spent less than Nu 100 on LPG per month, 57.60 spent less than Nu 500, and 29.49% up to Nu 1,000 per month. The cost included all transportation charges.

Table L-35: Expenses on LPG			
Expenditure on LPG per Month	**Frequency of HHS**	**Percentage**	**Percentage of Total**
Less than Nu 100	28	12.90	1.42
Nu 101 to 500	125	57.60	6.35
Nu 501 to Nu 1,000	64	29.49	3.25
Not applicable	1750	**100**	88.97
Total	**1967**		**100.00**

83. Because of the remoteness of the surveyed areas, it is difficult for households to get their LPG replaced. So the time spent on getting the LPG replaced was considerable. 63.59% of them spent more than 5 hours, while only 5.99% spent one hour.

Table L-36: Time Spent in Getting LPG Replaced		
Time spent on Getting LPG Replaced	**Frequency of HHs**	**Percentage**
One Hour	13	5.99
Between 1 to 2 hours	26	11.98
Between 2 to 5 hours	40	18.43
More than 5 hours	138	63.59
Total	**217**	**100.00**

84. Kerosene is the main source of fuel for lighting in the rural communities. 66.34% of the surveyed households spent less than Nu 100 per month on kerosene, while just 1.58% spent between Nu 500 and Nu 1,000.

Table L-37: Expenses on Kerosene		
Expenses on Kerosene	**Frequency of HHs**	**Percentage**
Less than Nu 100	1305	66.34
Nu 101 to Nu 500	631	32.08
Nu 501 to Nu 1,000	31	1.58
Total	**1967**	**100.00**

85. The time spent on fetching kerosene from the collection point varied among communities. 62.23% of the surveyed households took more than 5 hours in collecting kerosene, while only 9.91% took less than an hour to do so.

Table L-38: Time Taken on Collecting Kerosene		
Time spent on Getting Kerosene from Distribution Point	**Frequency of HHs**	**Percentage**
One Hour	195	9.91
Between 1 to 2 hours	217	11.03
Between 2 to 5 hours	331	16.83
More than 5 hours	1224	62.23
Total	**1967**	**100**

86. Torch light is an essential source of lighting during emergencies in the rural areas; torches are equally handy both for males and females as well as the aged. 98.42% of the surveyed households reported using torch light regularly.

Table L-39: Use of Torch Light		
Regular Use of Torch Light	**Frequency of HHs**	**Percentage**
Use regularly	1936	98.42
Do not use regularly	31	1.58
Total	**1967**	**100.00**

87. 89.17% of the households reported spending less than Nu 100 per month on torch cells, while 0.36% reported spending between Nu 501 and Nu 1,000.

Table L-40: Expenses on Batteries for Torch Light		
Expenditure of Batteries for Torch Light	**Frequency of HHs**	**Percentage**
Less than Nu 100	1754	89.17
Nu 101 to 500	175	8.90
Nu 501 to Nu 1,000	7	0.36
Do not purchase batteries	31	1.58
	1967	**100.00**

88. The primary source for heating homes by the communities is firewood, where 92.37% of households that require heating during the cold months use firewood. Of these households, 0.44% use LPG and 12.38% use kerosene as their secondary source of heating.

Table L-41: Sources of Energy Used for Heating						
Sources of Energy Used for Heating of House	**Primary Source**	**Percent**	**Secondary Source**	**Percent**	**Tertiary Source**	**Percent**
Firewood	1810	99.61	0	0	0	0
LPG	0	0	8	0.44	0	0
Kerosene	6	0.33	225	12.38	8	0.44
Other sources	1	0.06	11	0.61	2	0.11
Total	**1817**	**100.00**	**244**	**13.43**	**10**	**0.55**

89. 56.53% of the surveyed households own a radio, 12.25% own a tape recorder, and 4.12% own a TV. Radios are mainly operated using batteries (98.29%) and 1.71% reported using solar. Households reported using generators as well as batteries for operating tape recorders and car batteries for operating TVs. Households owning machinery and other gadgets mainly used kerosene (109 HHs), petrol (90 HHs) or diesel (50 HHs). 35 households also used batteries for operating machinery or gadgets.

Table L-42: Source of Energy for Entertainment						
Sources of Energy for Entertainment	**Radio**	**Percent**	**Tape Recorder**	**Percent**	**TV**	**Percent**
Battery	1093	98.29	189	78.42	14	17.28
Solar	19	1.71	31	12.86	14	17.28
Generator	0	0	21	8.71	53	65.43
Total	**1112**	**100**	**241**	**100.00**	**81**	**100.00**

90. Firewood is the most used source of energy followed by kerosene and LPG. Two households reported depending on pine shavings for their energy need.

Table L-43: Most Used Energy Sources		
Source of Energy Most Used	**Frequency of HHs**	**Percentage**
Firewood	1796	91.31
LPG	33	1.68
Kerosene	36	1.83
Batteries	3	0.15
Pine shavings	2	0.10
Others	23	1.17
No response	74	3.76
Total	**1967**	100.00

91. If connected to power grid, the most preferred electrical appliances are rice cookers (83.07% of households), followed by electrical bulbs (80.88%), electrical curry cookers (78.39%), and water boiler with (70.56%). Households in colder areas reported preferring electrical room heaters, while those in hotter regions reported preferring electrical fans.

Table L-44: Preference for Electrical Appliances Once Connected to the Power Grid		
Electrical Appliances Preferred	**No. of Households**	**Percentage of Households**
Electrical bulbs	1591	80.88
Electrical kettle	97	4.93
Electric rice cooker	1634	83.07
Electric mill	166	8.44
Electric curry cooker	1542	78.39
Refrigerator	485	24.66
Electric water boiler	1388	70.56
TV	934	47.48
Electric iron	163	8.29
Radio/cassette player	733	37.26
Electric fan	292	14.84
Electric room heater	340	17.29
Electric stove	110	5.59
Others (electrical drills/plainer)	15	0.76

5.10 Affordability

92. With the preference for the electrical appliances, households were asked about their affordability to pay the electricity bill to operate those appliances. 34.52% reported being able to pay up to Nu 100 per month, 26.08% being able to pay up to Nu 200, and 18.20% not responding.

Table L-45: Affordability to Pay Electricity Bill		
Affordability Range	**No. Households**	**Percentage of Households**
Up to Nu 100 pm	749	38.08
Up to Nu 200 pm	519	26.39
Up to Nu 300 pm	142	7.22
Up to Nu 400 pm	69	3.51
Up to Nu 500 pm	41	2.08
More than Nu500 pm	89	4.52
No response	358	18.20
Total	**1967**	**100**

5.11 Household Income and Expenditures

93. The source of income for the communities was ascertained from main economic activities such as agriculture, livestock, wage labor, remittances, and carpentry/painting/ masonry. Not all the households surveyed have income from all the sources. In order to get a realistic picture of household income and expenditures, the survey converted into monetary terms the farm produce, goods, and services reported during the survey and aggregated this value together with the cash incomes of households to arrive at yearly income and then monthly income. Households expenditures was determined and based on the information reported by the respondents also on a yearly basis then converted into monthly basis.

Sources of Income

94. Income from agriculture, livestock and off-farm labor constituted the major sources for most of the surveyed households. Agriculture income included the value of sales of agricultural products and the imputed value of just the agriculture crop produced and sold by the households. Income from wage labor may be underestimated, as some of the households would have been paid in kind, which could not be computed.

95. Not all the households had their income from all the sources. Some households had income from just one source, while others reported having income from more than one source. Although data on income from the sale of land were collected, they were not taken into consideration for computing, as sale of land does not take place periodically as income from other sources.

96. Expenditure patterns are presented in Table L-48. Expense on food was considered only for purchases of food grains. 77 households reported having no expenses on food, which indicates that their own grain produce is sufficient for their own use year round. Similarly, households that reported not having any expenses on clothing indicate that clothing for their households is supported by relatives living elsewhere. These households do not spend any money from their earnings on clothing.

Table L-46: Source and Range of Monthly Income of Households																
Income Range	**Agriculture**		**Livestock produce**		**Livestock**		**Sale of land**		**Off-farm Labour**		**Seasonal Trading**		**Remittances**		**Others (carpentry, painting, mason)**	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**Percent**	**Frequency**	**%**
Up to Nu 1,000	137	6.96	184	9.35	30	1.53	1	0.05	96	4.88	40	2.03	69	3.51	36	1.83
Nu 1,001 to Nu 5,000	286	14.54	306	15.56	94	4.78	4	0.2	327	16.62	164	8.34	268	13.62	159	8.08
Nu 5,001 to Nu 10,000	96	4.88	123	6.25	75	3.81	7	0.36	171	8.69	102	5.19	127	6.46	133	6.76
Nu 10,001 to Nu 20,000	75	3.81	60	3.05	52	2.64	3	0.15	102	5.19	122	6.2	64	3.25	159	8.08
Above Nu 20,000	37	1.88	25	1.27	33	1.68	8	0.41	81	4.12	110	5.59	45	2.29	136	6.91
No income	1336	67.92	1269	64.51	1683	85.56	1944	98.83	1190	60.50	1429	72.65	1394	70.87	1344	68.33
Total	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**

Table L-47: Average Income by Category						
Average Monthly income in Nu						
Agriculture	**Livestock Product**	**Livestock**	**Off-farm Labour**	**Seasonal Trading**	**Remittances**	**Others**
Nu 601	***Nu 477***	***Nu 840***	***Nu 799***	***Nu 1,311***	***Nu 710***	***Nu 1,318***
294 HHs from 2 sources						
60 HHs from 3 sources						
28 HHs from 4 sources						
8 HH from 5 sources						
Two HHs from 6 sources						
One HH having income from all sources						

Table L-48: Expenditure Pattern																							
Range of expenses	Food		Clothing		House		Education		Medicines		Travel		Religious ceremonies		Social occasions		Entertainment		Farm Machinery		Cattle	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Up to Nu 1,000	80	4.07	283	14.39	10	0.51	181	9.20	153	7.78	635	32.28	491	24.96	754	38.33	410	20.84	14	0.71	258	13.12
Nu 1,001 to Nu 5,000	704	35.79	1114	56.63	47	2.39	544	27.66	52	2.64	657	33.40	745	37.87	166	8.44	318	16.17	39	1.98	88	4.47
Nu 5,001 to Nu 10,000	491	24.96	246	12.51	47	2.39	291	14.79	13	0.66	132	6.71	276	14.03	31	1.58	21	1.07	19	0.97	40	2.03
Nu 10,001 to Nu 20,000	443	22.52	59	3.00	48	2.44	207	10.52	4	0.20	46	2.34	148	7.52	30	1.53	14	0.71	24	1.22	11	0.56
Above Nu 20,000	172	8.74	21	1.07	63	3.20	114	5.80	0	0	20	1.02	60	3.05	10	0.51	3	0.15	14	0.71	3	0.15
No expenses	77	3.91	244	12.40	1752	89.07	630	32.03	1745	88.71	477	24.25	247	12.56	976	49.62	1201	61.06	1857	94.41	1567	79.66
Total	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**	**1967**	**100**

5.12 Poverty Profile

97. The analysis considered the income classification of the households based on the monthly household income, grouped into four categories:

- subsistence poor (income of Nu 689 or less per person per month)
- below the poverty line (between Nu 689 – Nu 1,097 per person per month)
- middle class (those who earn between Nu 1,097 and Nu 2,500 per person per month), and
- well off (those who earn above Nu 2,500 per person per month)

98. Table L-49 reveals that 28.88% of the households surveyed comprise the "subsistence poor," suffering from food shortages and not having enough to eat. 14.44% fall below the national "poverty line" with an income of Nu 1,097 per person per month, but are above the "subsistence poor" category. 29.13% are categorized as "middle class" and 27.55% are considered as "well off."

Table L-49: Income Categories of Households

INCOME CATEGORY	No. of HHs	% of HHs
Subsistence poor (less than Nu 689 per month)	568	28.88
Below poverty line (between Nu 689 to Nu 1,097 per month)	284	14.44
Middle class (between Nu 1,097 to Nu 2,500 per month)	573	29.13
Well off (above Nu 2,500 per month)	542	27.55
Total	**1967**	**100**

99. The above figures indicate that 43.32% of the surveyed households fall below the national poverty line of Nu 1,097 per month, while 56.68% of the surveyed population is above the national poverty line.

100. 24.86% of the households face food shortages ranging from 1 month to 12 months per year. 3.72% of the households surveyed face severe food shortages, meaning that they have to rely on other sources for a period between 3 months to 12 months, 21.15% face moderate food shortages lasting up to 3 months, and 75.14% face no food shortage. The food shortages faced by households is the shortage of grains that they produce themselves, which are not sufficient for the family year round, and due to which they have to either buy food grains from the market or work for others and earn in-kind for sustenance.

Table L-50: Food Shortage Faced by Households		
Number of Months HHs Facing Food Shortage	**Frequency of HHs**	**Percent**
No Food shortages	1478	75.14
1 to 3 months	416	21.15
4 to 6 months	8	0.41
7 to 9 months	57	2.90
11 to 12 months	8	0.41
Total	**1967**	**100.00**

5.13 Preference to Electricity Connection

101. The surveyed households were asked about their preference for electricity connection. 98.68% preferred on-grid connection, while only 1.32% of households preferred off-grid electrification.

Table L-51: Preference for Electricity Connection		
Preference	**Frequency of Households**	**Percent**
On-grid	1941	98.68
Off-grid	26	1.32
Total	**1967**	**100**

102. The reasons cited for their preferences are that over 90% believe that on-grid electrification can be used for many purposes, 42.50% believe that it can be used to operate machines, 52.87% reported that it is available at all times, and 4.07% believe it is cheaper. For off-grid electrification, 1.22% believes that a solar home set does not require paying the monthly electricity bill, 0.61% reported it to be safer and 0.71% reported that it is easier to handle.

Table L-52: Reasons for Preference		
Reasons	**Frequency of HHs**	**Percent**
On-grid can be used for many purposes	1782	90.59
On-grid can operate machines	836	42.50
On-grid is available at all times	1040	52.87
Others (It is cheaper)	80	4.07
SHLS is better in terms of safety	12	0.61
No need to pay monthly bill for SHLS	24	1.22
Others (easy to handle)	14	0.71

103. 65.68% of the households reported that they will accept SHS if they are provided free of cost, while 34.32% said that they will not accept them. Those who reported that they will not accept SHS (675 households) were asked if they would accept them if long lasting bulbs/lamps were provided with the set. 507 households still reported that they would not accept SHS. Asked if they had any suggestions for the government so that people will accept SHS, 809 households reported that government should take care of the maintenance once the sets are provided, and 181 households mentioned that there should be some sort of backup during cloudy/rainy seasons.

Table L-53: Acceptance of SHLS if Provided Free of Cost

	Frequency of HHs	Percent
Will accept	1292	65.68
Will not accept	675	34.32
Total	**1967**	**100.00**

5.14 Preference in Continuing to Use Different Energy Sources

104. Once the households are connected with electricity, 74% reported that they will still continue purchasing kerosene, while 25% said that they will not purchase kerosene after electricity is connected. For those who reported to continue purchasing kerosene, the reasons cited were that it would be for emergency purpose (1279 HHs) and for lighting outside of their houses (152 households).

Table L-54: Reasons for Continuing to Purchase Batteries

Reasons for Purchasing Batteries	Frequency of Households	Percent
For emergency purposes	642	36.79
For torch light	1078	61.78
For radio	5	0.29
Other reasons (use for other gazettes)	20	1.15
Total	**1745**	**100**

105. 1,890 households mentioned that they will still continue to collect firewood and the reasons that they mentioned were that firewood will have to be used for preparing cattle feed, firewood is cheaper and readily available, and that during rituals firewood is essential. Firewood is an indispensable source of energy in rural areas and will remain so for some time to come.

Table L-55: Reasons for Continuing to Collect Firewood		
Reasons	**Frequency of Households**	**Percent**
For preparing cattle feed	1635	86.51
Firewood would be cheaper	131	6.93
Firewood is readily available	110	5.82
Other reasons (during rituals)	316	16.72

106. Table L-56 lists facilities/services according to the priority of the communities. 94.31% ranked electricity as their first priority followed by roads at 84.04%, education at 72.75% and health at 71.02%.

Table L-56: Community Priorities			
Needs	**Prioritization**	**Frequency of Households**	**Percent**
Electricity	1	1855	94.31
Road	2	1653	84.04
Education	3	1431	72.75
Health	4	1397	71.02
Vehicle	5	602	30.60
Pilgrimage	6	492	25.01
Recreation	7	478	24.30
Others (better houses, more land, irrigation)	8	81	4.12

5.15 Ability and Willingness to Pay

107. When assessing the ability and willingness to pay, two cost components have to be taken into account for households targeted for on-grid connection:

- the initial internal house wiring and meter security deposit costs
- the monthly electricity tariff.

For those households targeted for solar lighting, three components have been taken into account:

- The initial cost of the solar lighting components
- Monthly contribution for repair and maintenance
- Monthly contribution for replacement of batteries.

For those households who had 5 or more cattle were considered for biogas, the following was taken into account:

- Installation cost of biogas plant.

Ability and Willingness to Pay for Internal House Wiring (On-grid Connection)

108. During the survey, households targeted for on-grid connection were asked if they have the ability and willingness to pay for internal house wiring if it costs Nu 5,000 or more. 94.22% of those targeted for on-grid connection reported their ability and willingness to spend on internal house wiring out of their own earnings, while 5.78% reported not being able to do so.

Table L-57: Affordability for Internal House Wiring

Affordability	**Frequency**	**Percent**	**Percent of On-grid HHs**
Yes can afford for internal wiring	1514	77.07	94.10
No, cannot afford for internal wiring	95	4.73	5.90
Total	1609	81.80	
Solar	358	18.20	
Total	**1967**	**100**	**100**

109. Households that reported not being able to afford internal wiring were asked if they would be interested in paying internal wiring costs through installments. 10 households reported not being interested in doing so.

110. Of those targeted for on-grid connection, 23.62% reported being willing to spend up to Nu 1,000 for internal house wiring, 18.33% up to Nu 2,000 and 16.35% reported being willing to spend any amount. 21 households reported not being able to spend any for internal wiring.

Table L-58: Amount Willing to Spend on Internal Wiring

Range of Amount	**Frequency**	**Percent**
< Nu 1,000	380	23.62
Nu 1,001 to Nu 2,000	295	18.33
Nu 2,001 to Nu 3,000	154	9.57
Nu 3,001 to Nu 4,000	99	6.15
Nu 4,001 to Nu 5,000	136	8.45
Nu 5,001 to Nu 10,000	205	12.74
Nu 10,001 to Nu 20,000	56	3.48
Any amount	263	16.35
Will not be able to afford any	21	1.31
Total	**1609**	**100.00**

111. 95 of the households that reported not being able to afford any amount for internal house wiring were asked if they were interested in paying the internal wiring costs through installments if made available to them. 10 households still reported not being interested in doing so.

Table L-59: Paying Internal Wiring Costs through Installment		
Interested through installment	**Frequency of households**	**Percent**
Interested	85	5.28
Not interested	10	0.62
Total	**95**	**5.90**

112. A deposit for meter security is mandatory for electricity consumers. 2.30% of the surveyed households reported not being able to pay for meter security, while 97.70% mentioned that they are in position to pay the meter security deposit.

Table L-60: Affordability for Meter Security		
Affordability	**Frequency of households**	**Percent**
Can afford	1572	97.70
Cannot afford	37	2.30
Total	**1609**	**100.00**

113. Those households not being able to pay the meter security deposit were asked if they were interested in doing so through installments. Still, 9 households reported not being interested in paying with this option. The reason that they gave was they the households did not have any source of income.

Table L-61: Payment of Meter Security Deposit through Installment		
Interest in Installment	**Frequency of Households**	**Percent**
Interested through installment	28	75.68
Not interested through installment	9	24.32
Total	**37**	**100.00**

Ability and Willingness to Pay for the Monthly Electricity Bills

114. The respondents were asked about their willingness and ability to pay the expected monthly electricity bills. 140 households reported that they would be able to pay up to Nu 30 per month for electricity, while 27.53% of the on-grid targeted households reported that they would be able to pay between Nu 76 to Nu 100 per month. 10.19% of the households indicated being able to pay more than Nu 200 per month.

Table L-62. Willingness and Ability to Pay for the Monthly Electricity Bills		
Range of Amount	**Frequency of Households**	**Percent**
Up to Nu 30	140	8.70
Nu 31 to Nu 50	421	26.17
Nu 51 to Nu 75	177	11.00
Nu 76 to Nu 100	443	27.53
Nu 101 to Nu 150	148	9.20
Nu 151 to Nu 200	116	7.21
Over Nu 200	164	10.19
Total	**1609**	**100.00**

Ability and Willingness to Pay for Solar Home System

115. A total of 358 households were targeted for SHS (18.20% of the households surveyed). Assuming that one set of SHS costs Nu 30,000, respondents were asked about their ability and willingness to pay for the solar sets. Only 1% of the households reported being able to pay the actual cost, while 9% mentioned that they would not be able to pay anything.

Table L-63: Ability and Willingness to Pay for Solar Home Lighting System			
Range of Payment	**Frequency of Households**	**Percent**	**Percentage of Total of 1,967 Households**
Less than Nu 500	81	23	4
Nu 501 to Nu 1000	89	25	5
Nu 1,001 to Nu 3,000	57	16	3
Nu 3,001 to Nu 5,000	81	23	4
Up to Nu 10,000	11	3	1
Actual cost	5	1	0
Cannot pay anything	34	9	2
Total	**358**	**100**	**18**

116. Those who indicated not being able to pay the cost of the SHS were asked how much per month would they be able to pay if payment through installment was arranged. Over 50% of the respondents reported that they would be able to pay monthly installments of less than Nu 200, whereas 3.07% reported not being able to pay any.

Table 64: Willingness to Pay for the SHS through Monthly Installments			
Range of Amount	**Frequency of Households**	**Percent**	**Percent of Total of 1,967**
Less than Nu 100	96	26.82	4.88
Nu 100 to Nu 200	99	27.65	5.03
Nu 200 to Nu 300	58	16.20	2.95
Nu 300 to Nu 500	77	21.51	3.91
Nu 500 to Nu 700	0	0.00	0.00
Nu 700 to Nu 900	2	0.56	0.10
Will not be able to afford to pay anything	11	3.07	0.56
No response	10	2.79	0.51
Installment not required	5	1.40	0.25
Total	**358**	**100**	**18.20**

117. In order for the SHS to function smoothly and without breaking down, repairs and maintenance services are crucial. The households were asked how much they would be willing to pay per month for the services. Over 77% reported that they would be willing to pay up to Nu 50 per month, while 15.36% reported being able to pay more than Nu 50. 7.26% mentioned that they will not be in position to pay anything.

Table L-65: Willingness to Pay for Repair and Maintenance			
Range of Amount	**Frequency of Households**	**Percent**	**Percent of Total 1967**
Nu 20 to Nu 30	97	27.09	4.93
Nu 30 to Nu 40	106	29.61	5.39
Nu 40 to Nu 50	74	20.67	3.76
Above Nu 50	55	15.36	2.80
Who cannot pay anything	26	7.26	1.32
Total	**358**	**100**	**18.20**

118. SHS need battery replacement every three to five years to function efficiently. Households were asked how much they were willing to pay every month for battery replacement. Over 90% mentioned that they would be willing to pay Nu 60 or less, while 0.84% (3 HHs) reported being willing to pay more than Nu 250 every month. 10 households mentioned not being to pay anything.

Table L-66: Willingness to Pay for Replacement Solar Batteries			
Range of Amount	**Frequency of Households**	**Percent**	**Percent of Total 1,967 HHs**
Nu 30 or less	205	57.26	10.42
Nu 30 to Nu 60	121	33.80	6.15
Nu 60 to Nu 100	13	3.63	0.66
Nu 100 to Nu 150	6	1.68	0.31
Nu 150 to Nu 250	0	0.00	0.00
More than Nu 250	3	0.84	0.15
Cannot pay anything	10	2.79	0.51
Total	**358**	**100**	**18.20**

119. Paying a deposit for a solar battery was an option for the communities so that when their old battery needs replacement, the money deposited could be used to purchase a new battery in the future. This is a different option from the monthly minimum payment for a battery. 51.12% were willing to pay for the deposit, while 46.09% were not willing and 10 households not being able to pay anything.

Table L-67: Willingness to Pay a Deposit for Solar Battery Replacement			
Willingness to deposit	**Frequency of households**	**Percent**	**Percent of total 1967**
Willing	183	51.12	9.30
Not willing	165	46.09	8.39
Cannot pay anything	10	2.79	0.51
Total	**358**	**100**	**18.20**

120. Of the 183 households that were willing to deposit, 88 would deposit less than Nu 100, while 2 households would be willing to deposit more than Nu 600.

Table L-68: Amount of Deposit Willing to Pay for Battery Replacement			
Range of Amount	**Frequency**	**Percent**	**Percent of Total 1967**
Less than Nu 100	88	24.58	4.47
Nu 100 to Nu 300	81	22.63	4.12
Nu 300 to Nu 600	12	3.35	0.61
More than Nu 600	2	0.56	0.10
Not willing and not able to pay	175	48.88	8.90
Total	**358**	**100**	**18.20**

Ability and Willingness to Pay for Biogas Plant

121. There were 803 households that had 5 or more head of cattle, the minimum number of cattle required for a small size (4 cubic meters) biogas plant. So the questions on biogas were administered among these households. Among the 803 households, 12 were stall feeding their cattle, 398 practiced grazing cattle while another 393 practiced both stall feeding and grazing.

Table L-69: Cattle Rearing Practices			
Cattle Rearing Practice	**Frequency of Households**	**Percent**	**Percent of Total 1,967 HHs**
Stall feed	12	1.49	0.61
Graze	398	49.56	20.23
Stall feed and graze	393	48.94	19.98
Total	**803**	**100.00**	**40.82**

122. When asked about their awareness of biogas plants, 26% of the respondents replied that they had heard about them, while the rest had not. Of the 803 households, 184 were interested in installing a biogas plant, while only 148 were interested in investing in one. Of these 148 households, 100 were willing to invest from their own savings while 48 were not interested.

123. Of the 803 households, 253 showed interest in installing a biogas plant through loans if made available to them. 362 showed interest in a 50:50 subsidy arrangement.

Table L-70: Awareness about Biogas			
Awareness	**Frequency of Households**	**Percent**	**Percent of Total 1967**
Heard about biogas	211	26	11
Have not heard about biogas	592	74	30
Total	**803**	**100**	**41**

124. The byproduct of biogas plants is the bio-slurry, an organic fertilizer. 137 households reported using chemical fertilizers against 665 households that do not, and on average each household spent Nu 92.72 on fertilizer last year. It was only after explaining the functioning of the biogas plant to the respondents that they believed more in biogas plants.

Table L-71: Use of Chemical Fertilizers			
	Frequency of Households	**Percent**	**Percent of Total 1967**
Use chemical fertilizers	137	17.06	6.96
Do not use chemical fertilizer	665	82.81	33.81
No response	1	0.12	0.05
Total	**803**	**100.00**	**40.82**

125. Data on smoke-related diseases of the households revealed that 37.36% of those interviewed reported family members suffering from such diseases. Emission of smoke in the houses was primarily from the burning of fuelwood.

Table L-72: Family Members' Health Affected by Smoke from Burning Fuelwood			
Affected by Smoke	**Frequency of Households**	**Percent**	**Percent of Total 1,967 HHs**
Affected	300	37.36	15.25
Not affected	502	62.52	25.52
No response	1	0.12	0.05
Total	**803**	**100.00**	**40.82**

126. Of the 300 households whose members suffered from smoke-related diseases, 152 got medical treatment, where they spent amounts varying from Nu 200 to over Nu 5,000 over the last year.

Table L-73: Amount Spent on Smoke Related Diseases Due to Burning of Fuelwood			
Range of Amount	**Frequency of Households**	**Percent**	**Percent of Total 1,967 HHs**
Less than Nu 200	46	30.26	2.34
Nu 200 to Nu 400	11	7.24	0.56
Nu 400 to Nu 600	39	25.66	1.98
Nu 600 to Nu 1000	19	12.50	0.97
Nu 1000 to Nu 2000	11	7.24	0.56
Nu 2000 to Nu 5000	16	10.53	0.81
Above Nu 5000	10	6.58	0.51
Total	**152**	**100**	**7.73**

127. Because of the soot from the smoke emitted through the burning of fuelwood, communities need to clean up their houses/pots and pans. The reported amounts of time spent on cleaning are shown in Table L-74. 33.87% of the households spent more than an hour every day cleaning soot from pots and pans. 337 households reported their willingness to replace fuelwood with biogas, while 466 households where not willing to replace it.

Table L-74: Time Spent in Cleaning Soot Caused by Smokes of Burning Fuelwood			
Time (in minutes)	**Frequency of Households**	**Percent**	**Percent of Total 1,967 HHs**
Less than 20 Minutes	197	24.53	10.02
20 to 40 minutes	232	28.89	11.79
40 to 60 minutes	102	12.70	5.19
Over 60 minutes	272	33.87	13.83
Total	**803**	**100.00**	**40.82**

128. Respondents were asked for suggestions on implementing the biogas project. 363 of the respondents had suggested that 1) the government provide biogas plants to the communities free of cost, 2) someone in the community be trained on biogas plant construction and maintenance, and 3) more awareness and information be given about biogas plants.

Table L-75: Suggestions in Operating the Biogas Project			
	Frequency of Households	**Percent**	**Percent of Total 1,967 HHs**
Suggestions	363	45.21	18.45
No suggestions	440	54.79	22.37
Total	**803**	**100.00**	**40.82**

5.16 Perceptions on the Status of the Communities Once Provided with Electricity

129. The respondents may have different perceptions of their village and the community once electricity is provided. They also perceived some negative impacts of electricity and that the benefits would be different for men and women. Respondents have a strong belief that the villages will be better in terms of cleanliness and that it will be safer at night.

Table L-76: Perceptions on the Status of the Communities										
Degree of Belief / Perceived Impacts	**Very much**		**A little**		**Not at all**		**Don't know**		**Total**	**Percent**
	No. of HHs	**Percent**	**No. of HHs**	**Percent**	**No. of HHs**	**Percent**	**No. of HHs**	**Percent**		
The village/house will be better maintained in term of cleanliness	1686	85.71	276	14.03	2	0.10	3	0.153	1967	100
There will be better houses coming up in the villages	1214	61.72	670	34.06	32	1.63	51	2.593	1967	100
There will be more kinds of small businesses	953	48.45	867	44.08	75	3.81	72	3.66	1967	100
There will be more migrants coming back to	751	38.18	891	45.30	155	7.88	170	8.643	1967	100

Table L-76: Perceptions on the Status of the Communities										
Degree of Belief / Perceived Impacts	Very much		A little		Not at all		Don't know		Total	Percent
	No. of HHs	Percent	No. of HHs	Percent	No. of HHs	Percent	No. of HHs	Percent		
the village										
There will be less youth migration to cities	636	32.33	813	41.33	319	16.22	199	10.12	1967	100
Social life in the village will improve	1587	80.68	328	16.68	13	0.66	39	1.983	1967	100
It will be safer at night in the village	1674	85.10	246	12.51	28	1.42	19	0.966	1967	100
New services and commercial activities will be available in the village	959	48.75	814	41.38	45	2.29	149	7.575	1967	100
With electricity there will be more opportunities for employment and training	967	49.16	777	39.50	56	2.85	167	8.49	1967	100
After receiving electricity/solar lights, smoke-related diseases (cough, eye itch, tearful eyes) will be reduced	1537	78.14	368	18.71	24	1.22	38	1.932	1967	100
After receiving electricity/solar lights children will spend more time at home on studying which will improve their academic results	1627	82.71	287	14.59	22	1.12	31	1.576	1967	100
More information will be available through media	1569	79.77	370	18.81	20	1.02	8	0.407	1967	100
Burdens on women will decrease	1522	77.38	371	18.86	39	1.98	35	1.779	1967	100
Service delivery for women and child health care will improve	1477	75.09	415	21.10	38	1.93	37	1.881	1967	100
More women will be enrolled in NFE	1100	55.92	642	32.64	96	4.88	129	6.558	1967	100

130. Respondents also reported the negative impacts of electricity. 120 households believe that village traditions will decline once the community is connected with electricity, while 49 households believe that children will be adversely affected in the sense that they will start picking up bad habits from watching TV. Six of them reported that social evils can enter the villages, while 18 believe that electricity can be life threatening at times.

Table L-77: Perceived Negative Impacts of Electricity	
Negative Impact	No. of HHs
Village tradition would decline	120
Children would be adversely affected from watching TV	49
Social evils could come to villages	6
Others (It could be dangerous and life threatening at times)	18

131. Regarding benefits of electricity to men, respondents believe that men can do productive work even after dark, and that they can also help in household chores and help in looking after the kids while women do other work. Women respondents are of the opinion that

they can weave even after dark, carrying out household chores including cooking will be easier, and the house can be kept cleaner.

Table L-78: Benefits of Electricity on Men and Women		
Men	**No. of HHs**	**Percent**
1. Men can do productive work even after dark	889	45.20
2. Men can help household chores while women do productive work	469	23.84
3. Others (men can help look after kids)	31	1.58
Women		
1. Women can weave for longer hours	1087	55.26
2. Doing household chores becomes easier for women	1654	84.09
3. Children can be better looked after	905	46.01
4. Women can keep the houses cleaner	982	49.92
5. Others (cooking becomes easier)	98	4.98

6. PERCEIVED BENEFITS OF ELECTRICITY

132. Village level consultations were held with beneficiaries of solar lighting system in the project area to determine their perception about both the on-grid and the solar components and their potential benefits. Beneficiaries were well aware of the benefits of electricity. The following were some of the benefits reported by the beneficiaries. There were no separate consultations with the communities targeted for on-grid connection.

6.1 Perceived Improvement in Quality of Life

133. The most important benefit as expressed by the beneficiaries was that electricity would improve the overall quality of life. Beneficiaries reported that quality of life would improve through improved education, improved health, opportunities for extra income, a cleaner home environment, and a greater sense of security after dark.

6.2 Perceived improvement in Education

134. Beneficiaries said that electricity would greatly improve education. Currently, most of the school going children return home from school when it is almost dark after which they have very little opportunities for studies at home. Over time their performances in school declines and leads them to leave school. When students have to leave school from higher grades they are more likely to migrate out of the villages into urban areas and abandon their villages. With the help of electricity these students can improve their school performances and will enable

them to continue their studies. Electricity will also help more people who have missed formal schooling to get enrolled in the non-formal education system.

6.3 Perceived Improvement in Health

135. At present all of the villages surveyed use firewood for cooking and kerosene for lighting purposes. The smoke emitted from these leads to respiratory and eye ailments. Electricity will help reduce such incidences. Also because of the lack of electricity, it is difficult to keep houses clean because of the smoke emitted from the sources mentioned above.

6.4 Perceived Improvement in Communication

136. The present technology of communication demands the use of electricity. Technology such as mobile phones and internet facilities through the community information centers need electricity supply. Without the provision of electricity, these facilities will not benefit the rural communities. So the provision of electricity will go a long way in making the communities realize the benefits of communication technology.

6.5 Perceived Opportunities in Increased Income and Employment

137. Both men and women will benefit from electricity by way of carrying out more income generating activities such as weaving, carpentry, painting etc., which will be possible to do even after dark with lighting from electricity. Commercial activities such as small shops will enable communities to increase their income. The provision of electricity will also enhance the establishment of small and cottage industries powered by electricity such as food processing, handicrafts and other small and medium enterprises. These enterprises would employ local villagers, thereby generating much-need employment opportunities in rural areas.

6.6 Perceived Opportunities for Productive Time

138. With the provision of electricity, more labor-saving devices will be utilized such as electrical cooking devices. There will be less firewood collection to be done. The time saved can be utilized for more productive income generating activities.

6.7 Perceived Opportunities for Increase in Households Savings

139. Although some of the respondents reported firewood being cheaper than electricity, overall, electricity will be cheaper in the long run as it is heavily subsidized by the government.

Calculating the time factor for firewood collection, the average cost of firewood consumed by a single household comes to more than Nu 22 per day (Nu 660 per month). With electricity the expenditure will be much less as is evident from the electrified village. Expenses on smoke-related illness will be greatly curtailed.

6.8 Perception in Increased Sense of Security

140. People in the rural villages will feel more secure at night especially for women, who have to attend to children and the elderly.

6.9 Perceived Decrease in Rural-Urban Migration

141. When students drop out of school, they have a tendency to move out of the villages to look for better employment opportunities and better facilities in urban areas. With electricity these school drop-outs will be encouraged to remain in the villages and explore employment opportunities. Through recreation facilities coming to the villages and more information available through various sources of media, young people will be encouraged to remain in their villages.

6.10 Perceived Opportunities for More Social Interaction

142. There is a perception that people in un-electrified villages live a stereotypical lifestyle where they work in the fields the whole day, return home in the evening, have dinner and retire to bed very early. With the provision of electricity, there will be more interaction among neighbors where it will be more convenient to visit friends/neighbours.

6.11 Perceived Opportunities in Improving Pest/Wildlife Management

143. As mentioned earlier, rural people have the notion that electricity on its own will keep away wild animals. There were also other notions that electricity can be used to protect their crops from wild animals.

7. MONITORING AND EVALUATION

144. In order to measure the benefits of electrification in the project areas, a broad monitoring framework and baseline socio-economic profiles were established. The baseline socio-economic data of the project areas gathered from the survey conducted in this study can

be used to monitor the changes in the lives of the communities before and after the project (rural electrification).

7.1 Baseline Data

145. The results of the survey conducted during this project provide the socio-economic baseline for monitoring and evaluating the project. The core parameters/indicators for which data were collected in the survey are provided in Table L-79. The indicators can be used for the impact assessments in the "before and after" scenarios of the communities.

Table L-79: Indicators to Be Monitored

Indicator Group	**Specific Indicators/Parameters**
▪ Household characteristics	▪ Number and age of household members disaggregated by sex and occupation.
Housing characteristics and access to basic amenities	▪ Housing material. ▪ Access to drinking water and distance to water collection point ▪ Access to latrines
Literacy and education	▪ Number of literate members. ▪ Highest level of education attainment of adults. ▪ Children of school going age regularly attending school. ▪ Performance of school going children at the school. ▪ Number of adults and non-school going children getting enrolled in non-formal education.
Distance to amenities	▪ Distance to schools, health facilities, RNR center, road head, market, ▪ Access to credit facilities
Health	▪ Number of household members suffering from smoke-related respiratory infection mainly from smoke emitted from firewood and kerosene wick lamps. ▪ Number of household members suffering from sanitation-related disease ▪ Frequency of visits to the health service provider ▪ Distance to the health facility.
Economic activity	▪ Number of household members involved primarily in agriculture. ▪ Number of household members involved in livestock rearing. ▪ Number of household members employed in other trades such as retail shops, handicraft, craftsmanship, etc. ▪ Any additional income-generating activities that were not there before electricity. ▪ Debt because of electrification
Household income, expenditure and economic activities	▪ Sources and amount of monthly/yearly household income. ▪ Average monthly/yearly expenditure ▪ Subsistence agriculture and food sufficiency ▪ Changes in economic activities.

Table L-79: Indicators to Be Monitored	
	▪ Employment status of economically active members ▪ Household income by primary and secondary sources. ▪ Number of income earners per household. ▪ Changes in agricultural income-earning activities. ▪ Changes in off-farm income-earning activities. ▪ Monthly household income and expenditure amounts and mode of payments. ▪ General status of living standard in relation to poverty ▪ Diversification of income sources and enhancement of incomes
Asset ownership	▪ Land ownership and changes in agricultural patterns ▪ Livestock ownership and changes in livestock ownership pattern ▪ Electrical appliance ownership ▪ Farm machinery ownership ▪ Accessibility to communication such as phones
Energy usage and cost	▪ Average amount of monthly electricity bills paid. ▪ Average monthly kerosene consumption and its cost. ▪ Average monthly dry cell batteries consumption and its cost. ▪ Average monthly consumption of candles and its cost. ▪ Average monthly consumption of LPG and its cost. ▪ Average monthly consumption of other sources of energy and its cost.
Fuel-wood consumption	▪ Average monthly consumption of fuelwood. ▪ Number of household members involved in firewood collection. ▪ Number of hours spent in a day collecting firewood. ▪ Number of days in a month spent on firewood collection.
Migration	▪ Number of household members that have migrated out of the community, by age and sex. ▪ Number of household members that have migrated back into the community, by age and sex.
Electrical appliances	▪ Number and type of electrical appliances in use. ▪ Number of hours each appliance is used in a day.
Wildlife pest management	▪ Crops lost to wildlife. ▪ Number of family members involved in guarding crops from wild animals. ▪ Number of hours spent guarding crops from wild animals. ▪ Number of nights per month spent on guarding crops.

8. CONCLUSION

146. The importance of rural electrification in improving the lives of the rural communities has been recognized by the royal government. Therefore the government has given priority to rural electrification and has included rural electrification in the 10th FYP, which emphasizes electricity for all by 2013.

147. The provision of electricity in the rural areas will create the necessary environment for more income generating opportunities. Through the provision of rural electrification the establishment of small cottage industries will be possible for the communities. Electricity will also promote a cleaner environment, with additional benefits of replacing kerosene lamps, which emit smoke, with electric lights. The reduction in the consumption of firewood will also help preserve the environment. Rural electrification will also bring about equity in development.

148. The survey findings reveal that 43.32% of the sampled population lives below the national poverty line of Nu 1,097 per person per month. The provision of electricity will help communities fight against poverty. It will help the communities alleviate poor health and low literacy, and improve human and social capital, which are also considered elements of poverty. Rural electrification will help communities invest in technologies which in turn will help boost their income over time. Through RE rural information and communication will be made more effective through TV, radio, information centers, and phones. These technologies will be powerful tools in the reduction of poverty. In addition to stimulating economic growth, RE enhances the quality of services provided in outreach clinics and rural schools by enabling the use of equipment and materials that depend on electricity.

148. All the areas to be electrified under the project are very remote and isolated, and thus have been left behind in terms of developmental activities and other services. The provision of electricity to these areas will not only improve their quality of life but will also bolster economic activity and decrease their demand and consumption of polluting firewood and more expensive kerosene. There is a need for subsidizing rural electrification to the very poor who otherwise may not be able to reap the benefits fully because of their financial conditions.

150. In terms of gender women will benefit more than men from rural electrification and biogas as it is women who remain indoors and perform household chores. The provision of electricity will not only make their chores easier but will also improve their health since most of their respiratory and eye ailments are caused by the smoke emitted from firewood stoves and kerosene lamps.

151. In conclusion, the socioeconomic impacts of electrification will be very positive in nature and considerable in scale. These include the beneficial impacts accrued from:

- improved performances by students at school thereby improving their overall education status, as better lighting allows them to study for more hours
- reduced smoke-related diseases through decreases in smoke emitted from firewood stoves and kerosene lamps
- cleaner house environment as smokes emitted from firewood and kerosene lamps will be reduced
- increased productivity as time will be saved from firewood collection and the collection of kerosene from distant markets

- Increased income through savings in not having to purchase other fuel/energy sources and through weaving for longer hours and engaging in other income-generating activities
- more convenience in performing household chores at night
- better entertainment and recreational facilities, which will boost activities at night such as reading, watching television, and listening to the radio
- promotion of social visits and interaction even after dark, thereby promoting better social bonds
- more convenience in preparing for, performing, and conducting religious ceremonies and prayers
- more convenience in dealing with emergencies such as illnesses and child delivery at night.

152. The project is not foreseen to have any negative impacts to any indigenous people as there are no apparent barriers to indigenous people reaping the benefits of the project. Therefore, no special provisions or mitigation measures are required for indigenous people.

153. The poverty reduction potential of this project will be significant since rural electrification, including SHS and biogas, are pro-poor interventions that provide an avenue for supporting social progress through dispersing the benefits of electrification and use of clean renewable energy widely and equitably. The impact of RE is enormous among the smaller, more remote communities, where isolation presents a formidable challenge in combating poverty and improving the quality of life.

Annexure I

List o Dzongkhags, Geogs and Villages Surveyed for SHS					
Sl. No.	**Dzongkhag**	**Geog**	**Village**	**Connection type**	**No. of HHs surveyed**
1	Chukha	Bongo	Toktokha Gongma	Solar	27
		Bongo	Zamsa	Solar	4
		Getena	Doga	Solar	11
		Phuntsholing	Pachudara	Solar	11
Total of Dzongkhag					**53**
2	Dagana	Deorali	Deorali	Solar	16
		Lajab	Thasa	Solar	7
		Nichula	Samolay	Solar	6
		Tsendagang	Baragomtee	Solar	7
		Tseza	Tongtsho	Solar	8
Total of Dzongkhag					**44**
3	Paro	Tsento	Yaksa	Solar	8

List o Dzongkhags, Geogs and Villages Surveyed for SHS					
Sl. No.	**Dzongkhag**	**Geog**	**Village**	**Connection type**	**No. of HHs surveyed**
		Tsento	Lemchi	Solar	5
		Tsento	Choeding	Solar	3
Total of Dzongkhag					**16**
4	Punakha	Chhubu	Sewla	Solar	11
		Toewang	Nashikha	Solar	30
Total of dzongkhag					**41**
5	Samtse	Bara	Chingu	Solar	24
		Bara	Assamtsa	Solar	16
		Pagli	Halhalay (Thodray B)	Solar	3
		Samtse	Chellu	Solar	9
		Tading	Kamaibanjang	Solar	5
Total of Dzongkhag					**57**
6	Sarpang	Dekiling	Chowabari B	Solar	7
		Doban	Torkay	Solar	2
		Doban	Noopani	Solar	17
		Doban	Fedi	Solar	2
		Doban	Bichkhola B	Solar	4
		Jigmechholing	Ghaleychu	Solar	3
		Senge	Chota Tsirang	Solar	2
		Senge	Balatung Daragoan	Solar	4
Total of Dzongkhag					**41**
7	Tsirang	Phuentenchu	Jogitar	Solar	4
		Pataley	Majgaon	Solar	10
		Pataley	Mithuntar	Solar	7
		Beteni	Malbasey	Solar	9
Total of Dzongkhag					**30**
8	Wangdue	Athang	Lamga	Solar	11
		Athang	Samthang	Solar	10
		Athang	Thaphu	Solar	9
		Dangchu	Tarsar	Solar	7
		Daga	Wogayna	Solar	7
		Kashi	Bemjee	Solar	25
		Sephu	Sektang	Solar	7
Total of Dzongkhag					**76**
Total of Off-grid (Solar) Sample					**358**

Annexure II

List of Dzongkhags, Geogs and Villages Surveyed for the On-Grid Rural Electrification Project					
Sl. No.	**Dzongkhag**	**Geog**	**Village**	**Connection type**	**No. of HHs surveyed**
1	Chukha	Bongo	Upper Phasuma	Grid	1
		Dala	Rupang	Grid	11
		Getena	Bachu	Grid	29
		Phuntsholing	Sadhuma	Grid	3
		Sampheling	Pakchina	Grid	12
		Sampheling	Upper Pungena	Grid	11
Total of Dzongkhag					**67**
2	Dagana	Dorona	Sano Dorona	Grid	13
		Dorona	Nimtola Lower Village	Grid	20
		Geserling	Geserling	Grid	10
		Geserling	Tanju	Grid	9
		Geserling	Samtengang	Grid	15
		Kalidzingkha	Bartshap	Grid	20
		Kalidzingkha	Ayetosel	Grid	11
		Tsangkha	Budaychu	Grid	22
Total of Ddzongkhag					**120**
3	Haa	Sombaykha	Yaba	Grid	7
		Sombaykha	Tashigang	Grid	20
		Sombaykha	Shama	Grid	9
Total of Dzongkhag					**36**
4	Lhuntshe	Menjay	Chengling	Grid	7
		Kurtoe	Tapkang	Grid	15
		Kurtoe	Chazam	Grid	7
Total of Dzongkhag					**29**
5	Mongar	Silambi	Pangarteng	Grid	24
		Silambi	Dag	Grid	19
		Silambi	Nagorpam	Grid	15
		Silambi	Nagar	Grid	19
		Chaskhar	Atingkhar	Grid	10
		Gongdue	Pangthang	Grid	23
		Jurmey	Yaragla B	Grid	7
		Jurmey	Tulupe	Grid	7
		Jurmey	Korkhang	Grid	21
		Jurmey	Belam	Grid	16
		Jurmey	Pangthang	Grid	7
		Kengkhar	Tonglawoong	Grid	12

List of Dzongkhags, Geogs and Villages Surveyed for the On-Grid Rural Electrification Project					
Sl. No.	**Dzongkhag**	**Geog**	**Village**	**Connection type**	**No. of HHs surveyed**
		Kengkhar	Dungkar Gonpa	Grid	12
		Kengkhar	Dogsebee	Grid	5
		Kengkhar	Tshalabe	Grid	4
		Kengkhar	Tonglagonpa	Grid	7
		Kengkhar	Munma	Grid	2
		Kengkhar	Aringkhangme	Grid	9
		Thangrong	Ngarphentsng	Grid	10
		Thangrong	Lengkhar	Grid	11
		Tsakaling	Takambe	Grid	5
		Tsakaling	Ganglapong A	Grid	10
Total of Dzongkhag					**255**
6	Paro	Doga	Tenchekha	Grid	10
		Lungnyi	Jewphue	Grid	8
		Doetay	Dhasar	Grid	8
Total of Dzongkhag					**26**
7	Pemagatshel	Decheling	Kulamanti	Grid	10
		Decheling	Dungchhilo	Grid	4
		Dungmin	Woongborang	Grid	11
Total of Dzongkhag					**25**
8	Punakha	Guma	Bjabchung karm	Grid	4
Total of Dzongkhag					**4**
9	S/Jongkhar	Serthi	Woongthi	Grid	15
		Serthi	Tshothang A	Grid	15
		Serthi	Tshangphu	Grid	9
		Serthi	Phaji Gonpa	Grid	9
		Serthi	Changphu B	Grid	2
		Serthi	Dhanphu	Grid	11
		Serthi	Barkalangnang	Grid	38
		Serthi	Serjong	Grid	37
		Luri	Serthi	Grid	15
		Serthi	Phagchu	Grid	13
		Serthi	Manmola	Grid	20
		Serthi	Momring	Grid	20
		Serthi	Dapchahg	Grid	6
Total of Dzongkhag					**210**
10	Samtse	Denchukha	Shetekha	Grid	10
		Denchukha	Pungtha A	Grid	3
		Denchukha	Khadori	Grid	16
		Denchukha	Gabjee A	Grid	8

List of Dzongkhags, Geogs and Villages Surveyed for the On-Grid Rural Electrification Project					
Sl. No.	**Dzongkhag**	**Geog**	**Village**	**Connection type**	**No. of HHs surveyed**
		Denchukha	Damji	Grid	7
		Denchukha	Damiley	Grid	8
		Denchukha	Baseni	Grid	22
		Denchukha	Balukhola 2	Grid	9
		Pagli	Sukti	Grid	5
		Pagli	Ratay	Grid	5
		Pagli	Gombodara	Grid	13
		Pagli	Gashinggaon B	Grid	18
		Pagli	Dhamdara	Grid	3
		Pagli	Dalmthang	Grid	8
		Pagli	Ahalay sangla	Grid	4
		Samtse	uttaray	Grid	9
		Samtse	Mandrini all	Grid	8
Total of Dzongkhag					**156**
11	Sarpang	Doban	Teerkhola A	Grid	3
		Doban	Pangkey BHU Area	Grid	9
		Doban	Mongargoan	Grid	13
		Doban	Mauggoan	Grid	12
		Jigmechholing	Virgoan	Grid	9
		Jigmechholing	Tormey	Grid	6
		Jigmechholing	Samkhara	Grid	4
		Jigmechholing	Reti	Grid	4
		Jigmechholing	Mongargoan	Grid	5
		Senge	Khopen	Grid	17
		Tarathang	Rangdara	Grid	17
		Tarathang	Borochandasa	Grid	11
Total of Dzongkhag					**110**
12	T/ Gang	Uzerong	Gyenkhar B	Grid	17
Total of Dzongkhag					**17**
13	T/ yangtshe	Bumdeling	Womina	Grid	26
		Bumdeling	Sep	Grid	11
		Bumdeling	Samtenling	Grid	12
		Bumdeling	Ngalingma	Grid	12
		Bumdeling	Chen	Grid	6
		Bumdeling	Bamree	Grid	25
Total of Dzongkhag					**92**
14	Thimphu	Mewang	Tshaphu	Grid	2
		Mewang	Jadinkha	Grid	10
Total of Dzongkhag					**12**

List of Dzongkhags, Geogs and Villages Surveyed for the On-Grid Rural Electrification Project					
Sl. No.	**Dzongkhag**	**Geog**	**Village**	**Connection type**	**No. of HHs surveyed**
15	Trongsa	Nubi	Semphu Goenpa	Grid	4
		Nubi	Karshaong Pam	Grid	7
		Nubi	Jongthang	Grid	11
		Nubi	Gagarpam	Grid	4
		Nubi	Chela	Grid	6
		Nubi	Bjee pam	Grid	1
		Nubi	Bemjee	Grid	11
Total of Dzongkhag					**44**
16	Tsirang	Phuentenchu	Sapraili	Grid	4
		Phuentenchu	Phaladhay	Grid	13
		Phuentenchu	Kharkhola	Grid	10
Total of Dzongkhag					**27**
17	Wangdue	Gatshetsho Ghom	Hervatshia	Grid	5
		Nubi	Thangyel	Grid	3
		Ruepisa	Chebigang	Grid	11
		Sephu	Nangkha	Grid	15
Total of Dzongkhag					**34**
18	Zhemgang	Bardo	Bardang	Grid	2
		Bardo	Bardo	Grid	9
		Bardo	Digala	Grid	15
		Bardo	Khomshar	Grid	5
		Bardo	Phulabe	Grid	8
		Bardo	Udngbee	Grid	8
		Bjoka	Barpong Namayrang	Grid	4
		Bjoka	Gangdhar	Grid	7
		Goshing	Lamtong Lower	Grid	10
		Goshing	Lichibi Shinlong	Grid	8
		Goshing	Lingmapong B	Grid	8
		Goshing	Shamcholing upper	Grid	9
		Khomshar	Khomshar Bardang	Grid	6
		Nangkhor	Dhumkhay	Grid	24
		Nangkhor	Ngakhar	Grid	13
		Nangkhor	Tsaidang	Grid	12
		Ngangla	Kaktong B	Grid	6
		Ngangla	Marandhoe Tangodengma	Grid	11
		Ngangla	Shamcholing upper	Grid	1
		Ngangla	Sonamthang	Grid	38
		Ngangla	Thinleygang	Grid	12
		Phangkhar	Tashi B1 A	Grid	6

List of Dzongkhags, Geogs and Villages Surveyed for the On-Grid Rural Electrification Project					
Sl. No.	**Dzongkhag**	**Geog**	**Village**	**Connection type**	**No. of HHs surveyed**
		Phangkhar	Mamung Trong	Grid	5
		Phangkhar	Pantang A	Grid	42
		Phangkhar	Royal Manas Park	Grid	7
		Shingkhar	Chabi	Grid	5
		Shingkhar	Nimshong	Grid	16
		Shingkhar	Radhi	Grid	18
		Shingkhar	Shingkhar	Grid	2
		Shingkhar	Thajong	Grid	2
		Shingkhar	Thrisa	Grid	18
		Shingkhar	Trong	Grid	2
		Shingkhar	Womling	Grid	6
Total of Dzongkhag					**345**
Total of on-grid					**1609**

Annexure III
Public Consultations for Solar Home Lighting System Installation Project

154. Five public consultations were held in four representative dzongkhags with the households targeted for solar home installations. The consultant explained to the households that due to technical and economic constraints, the extension of electricity lines to their villages is currently not feasible. The government would provide solar home systems to them. The consultant also described how a SHS works, and indicated that there are no known adverse environmental impacts if the used batteries are fully recycled. The participating households were asked to provide comments and voice their concerns regarding the SHS installation program.

Public Consultation at Tongtsho Village-Tseza Geog, Dagana Dzongkhag, January 19, 2010

155. Seven households participated in the public consultation. They were not happy about receiving solar home systems as they preferred on-grid electricity connection. The participants also expressed concern about the feasibility of SHS as the weather at Tongtsho is mostly cloudy and under such conditions, they are not sure whether a SHS would work in their village.

Public Consultation at Doban Geog, Sarpang Dzongkhag, January 12, 2010

156. Fifteen participants attended the public consultation. Households' preference was for on-grid electricity connection. However, after the consultant explained the technical and economic constraints on the part of the government, participants showed their satisfaction

with solar home systems, but insisted that they be installed free of cost to them. One more concern expressed by the participants was that the batteries would be expensive and difficult to transport in case they needed replacement.

Public Consultation at Thasa Village, Lajab Geog, Dagana Dzongkhag, January 23, 2010

157. Five households participated in the public consultation and expressed that they would prefer getting connected with electricity distribution lines rather than receiving solar home systems. Their concern was the operation and maintenance of the systems as none of the people in the village have experience in solar home systems, while some of them have not even seen a SHS that is functioning properly.

Public Consultation at Upper Majgaon Village, Patalay Geog, Tsirang Dongkhag, January 28, 2010

158. The four participants in the meeting raised their concern about the skills required to handle the solar home systems. They indicated that they were not choosy about SHS verses on-grid electricity connection, but were more concerned about the replacement of batteries, handling the sets, disposing of the old batteries, and taking care of the solar panels. They also stressed that the solar home sets be provided free of cost to them. They also indicated they would be happier if the government can provide them with on-grid electricity connection if possible.

Public Consultation at Village Chota Tsirang/Sisty and Daragaon, Geog Sengye, Sarpang Dzongkhag, January 15, 2010

159. Twenty households participated in the public consultation. The participants were concerned about the type of solar home systems they would receive because some of the participants had witnessed defective SHS elsewhere. They believed that if SHS that may not work are provided to them, they would prefer on-grid electricity connection. The participants also raised concerns about the short supply of electricity during rainy and cloudy days and also the danger of the solar home lighting sets being stolen by miscreants from across the border in India. Overall, they preferred on-grid electricity connection.

Annexure IV
Stakeholders Consultation on the Proposed Biogas Program

160. Eleven stakeholders consultation workshops were held in 11 dzongkhags in January 2010. The workshops were organized with the dzongkhag officers, gewog officers, the Department of Livestock (DOL) district offices and/or Gewog extension offices. The participants were the rural framers who own more than 5 cattle. In each workshop, the consultant explained how a biogas plant works, the benefits and costs of biogas plants, and the key

features of the proposed biogas program. The consultant explained that after conversion, biogas that is piped into the kitchen for cooking and heating on demand. Biogas is a clean renewable energy that allows farmers to avoid the adverse health effect from firewood smokes and save time in collecting firewood, using it instead of other income generating activities. The byproduct of the bio-slurry is an odorless organic fertilizer that can be used to increase crop yields. There are no known adverse environmental or social impacts from biogas. The consultant asked about the participants' interest in participating in the proposed program to build and operate a biogas plant. The consultant also sought the participants' input on how the proposed program can be improved.

Public Consultation at Zhemgang, January 15, 2010

161. Present at the discussion were the dzongkhag livestock officer, the assistant dzongkhag livestock officer, and the head of the DOL Regional Development Training Center.

162. The public consultation at Zhemgang was arranged at the dzongkhag Livestock Office and was attended by 12 participants. The participants were from the Trong Geog and own more than five cattle. The meeting started with a briefing from the consultant on biogas plant and its benefits and costs. Most of the participants had heard about biogas before.

163. The participants were asked about the types of fuel they use at home and all of them mentioned using LPG gas as well as firewood. Firewood was used mainly for preparing cattle feed and brewing alcohol, whereas LPG gas was used for preparing food. On average, each household possessed the LPG cylinders and each cylinder lasted for a month and Nu 375 per filled cylinder. When asked about the conveniences of firewood and LPG gas, they mentioned that collecting firewood is a problem as they have to get permit from the forest office for felling trees and hire labor to chop the felled trees. On average, each household spends money for two laborers for about 15 days per year. Inconveniences (e.g., frequent house and utensil cleaning) caused because of smokes emitted from burning firewood were also mentioned by the participants.

164. The participants were more interested in the cost aspect of biogas and when told that each plant would cost in the range of Nu 26,000 to Nu 35,000, 50% of them mentioned that they are willing to invest in the plant, provided it worked properly. The rest inquired about the possibility of government loans. Given the situation that the plant worked satisfactorily and the cost was within the mentioned range, all of them were willing to invest in the plant and make the required land available for its construction.

Public Consultation at Chaskhar, Mongar, January 17, 2010

165. There were 15 participants present at the discussion along with the Gup of the Geog, the district DOL officer, Mr. Tashi, and the Geog livestock officer. Participants had heard about biogas and when only 12 participants were invited, 15 turned out just because of their interest in biogas. Chaskhar has a very high rate of cattle holding and about four or five participants stall

feed their cattle. The average number of cattle holding is over 9 heads and firewood is a big problem for the community. Households get firewood in truckloads year round. Only one house indicated it had LPG gas. Household income is relatively high in these areas, indicating their ability to invest in the biogas plant using their own earnings. All the participants are eager to install the plant. The livestock extension staff is also eager to give his best input into this project. Overall, Chaskhar has a very high potential of taking up the biogas project. However, some participants indicated they will be very interested in investing a biogas project that if there is a subsidy from the government.

Public Consultation at Pam Trashigang, January 23, 2010

166. Present at the consultation were the district DOL officer and the Geog livestock officer. Cattle holdings among the nine participants average five to six head, which are mostly stall fed. The community had been made aware of the potential biogas project from the government through the previous market survey done by the SVN. Most of the participants (except two) had an interest in installing a biogas plant, but were reluctant because of the fear that a biogas plant will not work. All of them wanted another house to install a plant first and if it worked satisfactorily, then every household wants to install one for them. Only one household indicated a willingness to take the risk of installing the plant. Firewood is a severe problem to the community as it becomes increasingly scarce, coupled with labor shortages. Because of the firewood problem, all the households use LPG gas for cooking besides electricity.

Public Consultation at Gumang, Shumar Geog at Pemagatshel, January 19, 2010

167. There were 14 participants present at the consultation. The assistant dzongkhag livestock officer was also present together with the Geog livestock officer.

168. The community of Gumang is relatively well to do and none of them had heard about biogas plants. The cost of a cylinder of LPG gas is about Nu 500 including transportation. Firewood is scarce. Every participant present at the discussion wanted to install a biogas plant in his/her house. All of them are willing to invest the total amount, despite having to borrow from other sources. However, if there is a subsidy from the government for installing a biogas plant, they would be very interested. The participants hold over 7 heads of cattle of a hybrid variety. Participants were more concerned about the technical aspects of the biogas plant and they wanted to make sure that the plant will work satisfactorily after installation. Only two households have LPG and the rest fetch firewood from the forest, spending a minimum of one hour each per day.

Public Consultation at Dewathang, Samdrup Jonkhar, January 19, 2010

169. Thirteen farmers attended the consultation workshop, but none of them had heard about biogas before. The average holding of cattle is over eight heads per household of a hybrid variety. The capital investment requirement for a biogas plant for the households was not a

concern to most participants except for two households as all of them had sufficient capital to invest. The technical aspects of the project were a concern voiced by all the participants.

170. Communities within the locality spent about two hours for one backload of firewood and consume about two backloads per day. Only one household uses LPG for cooking and the rest use firewood for all purposes. The willingness to pay and affordability of a biogas plant was high; however, only two are readily willing to invest immediately and the others indicated that they would invest only upon seeing such a plant work satisfactorily.

Public Consultation at Patabari, Sompangkha Geog at Sarpang Dzongkhag, January 20, 2010

171. There were 10 participants along with the dzongkhag livestock officer and the Geog livestock officer.

172. All the participants had heard about biogas plants and all of them had seen one across the border in the neighboring Indian village. Since what they saw across the border was working perfectly, all of them were motivated to invest in such a plant as they have enough cattle. Each household has both hybrid cattle as well as the local breed. They had even approached a technician across the border about installing such plants in Patabari through their own funding, but the technician did not come. With the new information on biogas plants they got from this consultation workshop, they were even more encouraged to install and self-finance plants. Their only request was not for funding, but for a technician from the government to assist in the construction of the plants to ensure the plants work properly. The materials available locally would be arranged by the participants. Immediately after this public consultation, the participants got together to prepare a written request to the dzongkhag livestock officer for a technician and wanted to start the construction immediately.

Public Consultation at Tsholingkhar Geog at Tsirang Dzongkhag, January 22, 2010

173. The workshop, which was attended by 15 people, started with a briefing from the consultant followed by a detailed explanation on how a biogas plant works, what are the prime requirements and costs, and what are the benefits. All the participants were interested in installing one in their houses. However, all of them would want to borrow from the project as they cannot afford to invest the total amount of Nu 35,000 at one go through their own means. Participants were also concerned about the technician on the construction of the plant. Their request was that the technician be provided by the project as the local technician would not be able to construct a plant that works properly.

Public Consultation at Trashiding Geog at Dagana Dzongkhag, January 23, 2010

174. Ten participants along with Mr. Namgay Sherpa, the Geog livestock officer, attended the workshop. The consultant started with a briefing followed by a detailed explanation on how the plant works, and what are the costs and benefits. The level of interest of the participants was high and three of them were interested in installing such a plant in their homes. The rest

commented that if the plants installed by their colleagues work, they would be interested in installing one in their homes. All the participants were eager to know the kind of support that the government would be providing to the communities for this project. The loan to be made available for such project, even at the household level, was well received by the participants. The participants who were eager to start one at their homes were also into other livestock activities such as poultry. These farmers can also use the byproduct of a biogas plant, the bio-slurry, as their poultry feed.

Public Consultation at Gatshel Gom, Geog at Wangdue Dzongkhag, January 24, 2010

175. Ten participants were present at the meeting along with Mr. Thubten Dorji, the Geog livestock officer. The meeting began with a briefing on the project followed by a detailed explanation on how the plant works, and the benefits and costs of a biogas plant. Initially the participants opted for a common plant for the whole community, as the houses are clustered, but after a brief debate, they opted for individual plants as the functionality of a common plant would be questionable in the long run. Once the project is implemented by the government, the participants indicated that they will be interested in a loan for installing individual plants at their homes. They indicated that such a project would not only help them deal with the firewood shortage problem but also save their time and manpower on the collection of firewood. They also indicated that houses would be cleaner due to less smoke from firewood.

Public Consultation at Lhakhu village under Guma Geog at Punakha Dzongkhag, January 24, 2010

176. 21 farmers were present at this meeting. The consultation began with a briefing about the project followed by a detailed explanation on the functioning, costs and benefits of a biogas plant. In the past, the community had a common biogas plant but due to functionality problems, the plant had ceased operation. Overall, just one participant showed interest in installing such a plant at his house. Despite informing them about the loan provision by the government, the participants indicated they were hesitant to invest. The rest of the participants indicated that the cost factor was a bit too much for them. They even debated on a common plant to serve the community, but concluded that individual plants would be preferred over a common one.

Public Consultation at Tsakaling Village under Yoeseltse Geog at Samtse Dzongkhag, January 28, 2010

177. 22 participants attended the consultation workshop along with the Gup of Yoeseltse and the assistant Geog livestock officer. The workshop started with the introduction to and thorough explanation of the biogas plant. All the participants were new to biogas technology and had never heard about such a plant. They were interested in the functioning of such a technology and in installing a plant in the long run. All of them were also interested in the funding modality as they mentioned that investment through their own savings would not be possible. The Gup, the Tshogpa and the assistant Geog LIvestock officer indicated that a model

plant could first be installed in the Geog so that people from the other villages of the Geog and people from other Geogs could see such a plant functioning, which in turn would encourage them to invest. Firewood is a big problem for the communities of the Geog as it is getting scarcer, and the participants agreed that such a plant would save them time, money and labor from collection of the firewood from the forest.

Appendix M

FINANCIAL AND ECONOMIC MODELS AND WORKSHEETS DEVELOPED OR USED

The following models and Excel spreadsheets were developed and used in various analyses in this TA:

- Financial performance analysis and projection model for Bhutan Power Corporation
- Financial performance analysis and projection model for Bhutan Development Finance Corporation
- Financial internal rate of return analysis model for on-grid RE, off-grid RE, and wind power and biogas pilot project components
- Economic internal rate of return analysis model for on-grid RE, off-grid RE, and wind power and biogas pilot project components
- Economic internal rate of return analysis model for diesel generation alternative.

These models and spreadsheets are included in a CD attached to the final report.