

**Ministry of Industry, Mines and Energy
in the Kingdom of Cambodia**

**THE MASTER PLAN STUDY
ON
RURAL ELECTRIFICATION
BY
RENEWABLE ENERGY
IN THE KINGDOM OF CAMBODIA**

**FINAL REPORT
VOLUME 4: PRE-FEASIBILITY STUDY**

June 2006

Japan International Cooperation Agency

**NIPPON KOEI CO., LTD., Tokyo
KRI INTERNATIONAL CORP., Tokyo**

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Preface

In response to the request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct the Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia, and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent the Study Team, headed by Mr. Akio KATAYAMA of Nippon Koei Co., Ltd. and organized by Nippon Koei Co., Ltd. and KRI International Corp., to Cambodia six times from October 2004 to June 2006.

The Study Team had a series of discussions with the officials concerned of the Government of the Kingdom of Cambodia and Ministry of Industry, Mines and Energy, and conducted related field surveys. After returning to Japan, the Study Team conducted further studies and compiled the final results in this report.

I hope that this report will contribute to the promotion of the plan and to the enhancement of amity between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia, Ministry of Industry, Mines and Energy for their close cooperation throughout the Study.

June 2006

Tadashi IZAWA
Vice President
Japan International Cooperation Agency



NIPPON KOEI CO., LTD.

in association with

KRI International Corp.

Japan International Cooperation Agency (JICA) Study Team

The Master Plan Study on the Rural Electrification by Renewable Energy in the Kingdom of Cambodia

Address: JICA Study Team, C/O Ministry of Industry, Mines and Energy

June 2006

Mr. Tadashi IZAWA,
Vice President,
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit herewith the Final Report of the Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia. We, Nippon Koei Co., Ltd. and KRI International Corp., studied the Master Plan for about twenty months from October 2004 to June 2006 under agreement with your Agency.

Presented in the Master Plan are goals of the rural electrification sector of Cambodia with planning time horizon in 2020 as well as the proposed short-term and medium-term policy measures essential for achieving the goals. It has been planned that the rural electrification in Cambodia be accomplished by utilizing two main vehicles, viz., government driven grid extension (on-grid) and private/community driven electrification in the off-grid areas surrounding the on-grid areas.

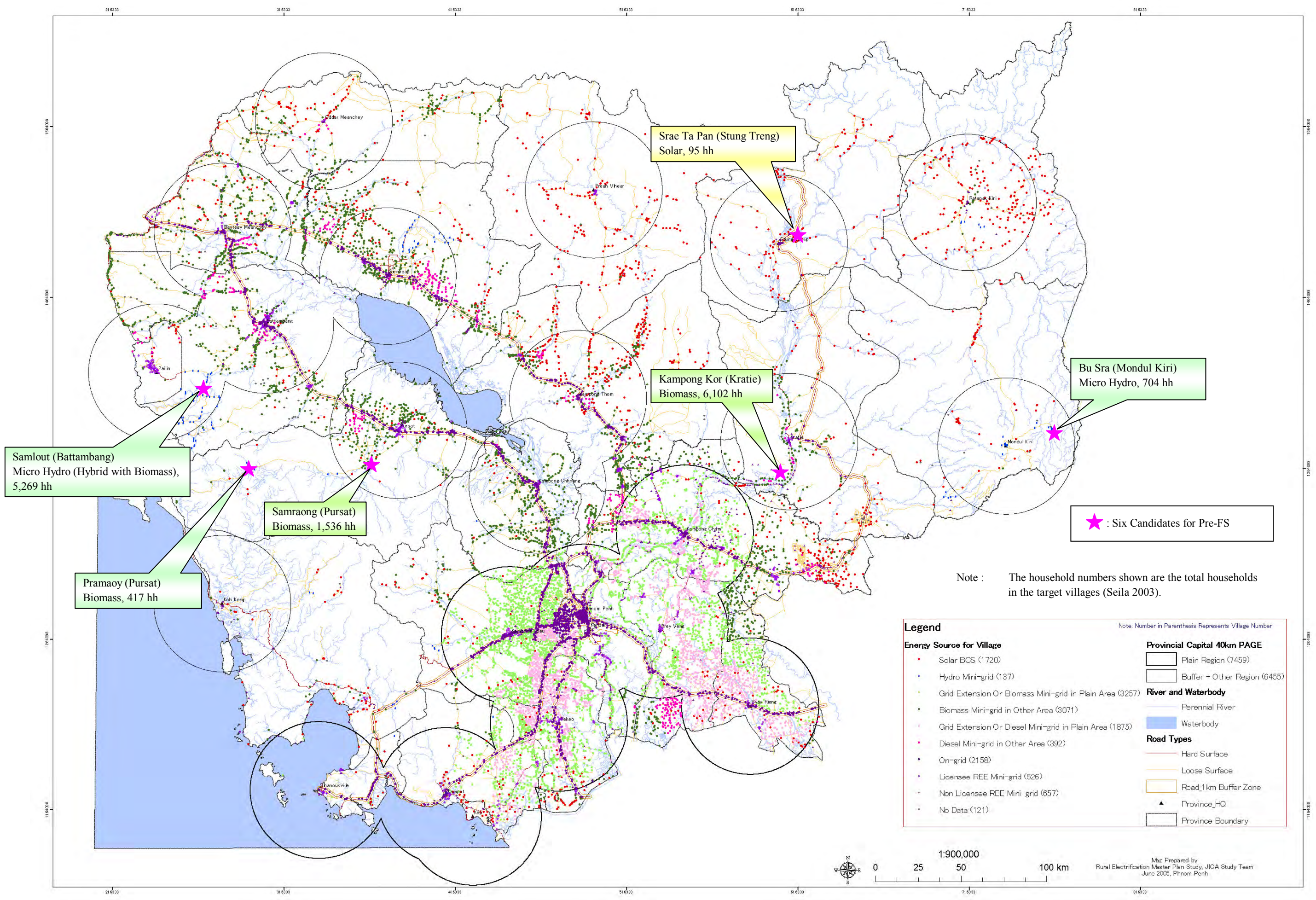
In order to promote awareness and understanding of the private/community driven electrification projects in the off-grid areas, we have - in addition to the Final Report - prepared a visual guide to serve as an illustrated version of the electrification manual. The Visual Guide is in Khmer and English. We hope that the Final Report and the Visual Guide will be instrumental in improving the level of rural electrification as well as for rural development.

We wish to take this opportunity to express our sincere gratitude to entities such as, the Ministry of Industry, Mines and Energy (MIME), Electricity Authority of Cambodia (EAC), Electricite du Cambodge (EdC), and the other related ministries in the Kingdom of Cambodia. We also wish to express our deep gratitude to the Embassy of Japan in Cambodia, the JICA Headquarter, the JICA Cambodia Office, and JICA experts, for the cooperation and assistance they extended to our Study Team during field investigations and studies in the Kingdom of Cambodia.

Very truly yours,

Akio KATAYAMA, Team Leader,

The Master Plan Study
on Rural Electrification by Renewable Energy
in the Kingdom of Cambodia



Samlout (Battambang)
Micro Hydro (Hybrid with Biomass),
5,269 hh

Pramaoy (Pursat)
Biomass, 417 hh

Samraong (Pursat)
Biomass, 1,536 hh

Srae Ta Pan (Stung Treng)
Solar, 95 hh

Kampong Kor (Kratie)
Biomass, 6,102 hh

Bu Sra (Mondul Kiri)
Micro Hydro, 704 hh

★ : Six Candidates for Pre-FS

Note : The household numbers shown are the total households in the target villages (Seila 2003).

Legend

Energy Source for Village

- Solar BCS (1720)
- Hydro Mini-grid (137)
- Grid Extension Or Biomass Mini-grid in Plain Area (3257)
- Biomass Mini-grid in Other Area (3071)
- Grid Extension Or Diesel Mini-grid in Plain Area (1875)
- Diesel Mini-grid in Other Area (392)
- On-grid (2158)
- Licensee REE Mini-grid (526)
- Non Licensee REE Mini-grid (657)
- No Data (121)

Provincial Capital 40km PAGE

- Plain Region (7459)
- Buffer + Other Region (6455)

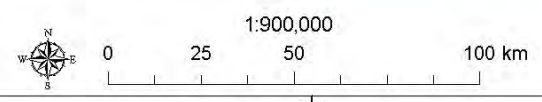
River and Waterbody

- Perennial River
- Waterbody

Road Types

- Hard Surface
- Loose Surface
- Road_1km Buffer Zone
- Province_HQ
- Province Boundary

Note: Number in Parenthesis Represents Village Number



Map Prepared by
Rural Electrification Master Plan Study, JICA Study Team
June 2005, Phnom Penh

Source of Energy by Village and 6 Candidates for Pre-FS

Abbreviations

Abbreviation	Description
ADB	Asian Development Bank
Ah	Ampere hour
ASEAN	Association of South East Asian Nations
ATP	Ability to Pay
BCS	Battery Charging Station
CBO	Community Based Organization
CDC	Council of Development for Cambodia
CDM	Clean Development Mechanism
CEC	Community Electricities Cambodia
CF	Community Forestry
CFR	Complementary Function to REF
CIDA	Canadian International Development Agency
DAC	Development Assistance Committee
DIME	Department of Industry, Mines and Energy
DNA	Designated National Authority
EAC	Electricity Authority of Cambodia
EdC	Electricite du Cambodge
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
ESA	Energy Service Agent
ESCO	Energy Service Company
EU	European Union
FIRR	Financial Internal Rate of Return
FS	Feasibility Study
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GS	Grid Substation
GWh	Giga Watt hour (one million kWh)
ha	hectar
HQ	Head Quarters
HV	High Voltage
IBRD	International Bank for Reconstruction and Development
IEE	Initial Environmental Examination
IEIA	Initial Environmental Impact Assessment
IMF	International Monetary Fund
IPP	Independent Power Producer
IRR	Internal Rate of Return
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
kW	kilo Watt
kWe	kW-electricity
kWh	kW-hour
kWp	kW-photovoltaic

Abbreviation	Description
MDG	Millennium Development Goals
MEF	Ministry of Economy and Finance
MHP	Micro-hydro Power
MIME	Ministry of Industry, Mines and Energy
MOE	Ministry of Environment
MOI	Ministry of Interior
MOWRM	Ministry of Water Resources and Meteorology
MP	Master Plan
MRC	Mekong River Commission
MV	Medium Voltage
MW	Mega Watt
NASA	National Aeronautics and Space Administration
NEDO	The New Energy and Industrial Technology Development Organization
NGO	Non-Governmental Organization
NIS	National Institute of Statistics
O&M	Operation and Maintenance
ODA	Official Development Assistance
PAGE	Potential Area of Grid Electrification
PEC	Provincial Electricity Company
PEU	Provincial Electricity Utility
PPP	Public Private Partnership
RDB	Rural Development Bank
REE	Rural Electricity Enterprise
REF	Rural Electrification Fund
RET	Renewable Energy Technology
RFP	Request for Proposal
RGC	The Royal Government of Cambodia
RPC	Regional Power Company
SA	Special Account
Seila	Seila is a Khmer word that means a foundation stone. The Seila Program initiated officially in 1996 institutes decentralized systems and strategies for poverty alleviation and good governance at the provincial and commune levels.
SHS	Solar Home System
SMEC	Small and Medium Enterprise Cambodia (NGO)
SPC	Special Purpose Company
SW	Scope of Works
TA	Technical Assistance
UNDP	United Nations Development Program
USAID	United States Agency for International Development
VAT	Value Added Tax
VO	Village Organization
WB	World Bank
WTP	Willingness to Pay
WWII	World War II

**THE MASTER PLAN STUDY
ON
RURAL ELECTRIFICATION BY RENEWABLE ENERGY
IN THE KINGDOM OF CAMBODIA**

FINAL REPORT

Volume 1	Summary
Volume 2	Master Plan
Volume 3	Manuals
Volume 4	Pre-feasibility Study
Volume 5	Appendices

PRE-FEASIBILITY STUDY

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Part 2	Samlout Electrification Plan
Part 3	Bu Sra Electrification Plan
Part 4	Pramaoy Electrification Plan
Part 5	Samraong Electrification Plan
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Part 7	Srae Ta Pan Electrification Plan

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Volume 4 Pre-feasibility Study

PART 1 SUMMARY

1. SCOPE OF STUDY AND SCHEDULE

Pre-feasibility studies of six schemes were conducted to show samples of formulating electrification plans for off-grid areas. Methods for formulating electrification plan are described in volume 3 – Manuals.

Stages	'04	'05											
	12	1	2	3	4	5	6	7	8	9	10	11	12
Baseline Survey													
Master Plan													
Pre-FS													

Figure 1 Study Stages and Schedule

For the period from December 2004 to March 2005, desk studies and field surveys were conducted as baseline survey (Baseline Survey Stage) and to formulate a master plan (Master Plan Stage).

From September to December 2005, further technical field survey and community workshops were conducted for additional collection of technical data and survey for community's ability for electrification. These works aimed at formulation of electrification plans for the selected six schemes for pre-feasibility study (Pre-FS Stage).

2. SELECTION OF CANDIDATE SITES FOR PRE-FEASIBILITY STUDY

In accordance with the selection criteria of master plan, priority schemes were selected for pre-feasibility study. Six candidate schemes were selected for three energy sources. Three were selected for micro hydro, two for biomass, and one for solar power. These six pre-FS schemes are as shown in Table 1. Seila 2003 data was applied for formulation of electrification plan and pre-feasibility study as the latest available data.

Table 1 Pre-FS for Promising Schemes

No.	Province	Scheme	Type	Energy Source	Total household numbers in the target area
1	Battambang	Samlout	Regional mini-grid	MHP + Biomass	5,269
2	Mondul Kiri	Bu Sra	mini-grid	MHP	704
3	Pursat	Pramaoy	mini-grid	Biomass	417
4	Pursat	Samraong	mini-grid	Biomass	1,536
5	Kratie	Kampong Kor	Regional mini-grid	Biomass	6,102
6	Stung Treng	Srae Ta Pan	BCS	Solar	95
Total	-	-	-	-	14,123

Source: JICA Study Team *: Household numbers are based on Seila 2003.

Locations of each scheme are shown in the opening location map together with village electrification energy source. Three micro hydro schemes and two biomass schemes were studied as energy sources for mini-grid, and one solar power scheme was studied as an energy source for battery charging station (BCS).

Out of micro hydro power schemes, Samlout scheme in Battambang Province is an example of regional mini-grid, with hybrid energy sources of micro hydro and biomass. Bu Sra scheme in Mondul Kiri Province is an example of micro hydro utilizing waterfalls in remote area.

Pramaoy scheme in Pursat Province was initially planned as micro hydro power scheme. However, as a result of comparison with electrification by biomass, biomass as energy source was concluded to be more economically efficient. Micro hydro can be considered as base load power station in addition to biomass power. For this, it is necessary to re-examine daytime demand growth and dry season potential of micro hydro before the second phase development.

Samraong and Kampong Kor schemes are examples for electrification by biomass. Kampong Kor scheme has a possibility to expand its electrification area to more than 6,000 households as a regional mini-grid.

Srae Ta Pan scheme is an example of solar BCS. BCS is for bottom up the village electrification level for those villages with low ability to pay.

3. PLAN FORMULATION

Principal features of each electrification schemes are as summarized in Table 2.

Counterpart staffs in MIME and JICA Study Team jointly conducted field survey and interview, community workshop, data collection and analysis. Through these joint works, electrification plans for six candidate schemes were formulated.

Table 2 Principal Features of Each Electrification Plan

No.	Scheme Name		Installed Capacity	Distribution Line			Construction Cost
				MV	LV	MV+LV	
1	Samlout (MHP & BGP Hybrid)	Phase 1	BGP 120 kW	6.3 km	2.5 km	3.7 km	\$559,000
		Phase 2	MHP 180 kW BGP 282 kW	53.9 km	7.0 km	22.6 km	\$4,769,200
		Phase 1&2	Total 582 kW	60.2 km	9.5 km	26.3 km	\$5,328,200
2	Bu Sra		MHP 80 kW	1.0 km	2.8 km	8.1 km	\$534,000
3	Pramaoy (BGP or BGP & MHP Hybrid)	Phase 1	BGP 20 kW	0.0 km	3.0 km	0.0 km	\$86,000
		Phase 2	BGP 25 kW (Alternative: MHP 45 kW)	5.0 km	1.0 km	2.0 km	\$107,200
		Phase 1&2	Total 45 kW	5.0 km	4.0 km	2.0 km	\$193,200
4	Samraong (BGP)	Phase 1 (Plan 3)	64 kW	0.0 km	2.5 km	0.0 km	\$219,300
		Phase 2	116 kW	0.0 km	0.0 km	11.5 km	\$873,700
		Phase 1&2 (Plan 1)	180 kW	0.0 km	2.5 km	11.5 km	\$1,093,000
5	Kampong Kor (BGP)	Phase 1	120 kW	2.5 km	2.0 km	6.0 km	\$689,100
		Phase 2	520 kW	11.3 km	9.0 km	27.0 km	\$2,586,500
		Phase 1&2	640 kW	13.8 km	11.0 km	33.0 km	\$3,275,600
6	Srae Ta Pan (Solar BCS)		Solar 4 kW	Battery Charging Station (BCS)			\$31,800

(Source: JICA Study Team)

BGP: Biomass Gasification Power, MHP: Micro Hydro Power
MV: Medium Voltage, LV: Low Voltage, BCS: Battery Charging Station

4. ECONOMIC AND FINANCIAL ANALYSIS

Economic analysis was made to evaluate viability of selected schemes. Appropriate tariff level was also calculated referring to socioeconomic conditions and the ability-to-pay of target electrification area. By assuming tariff level, financial viability was also evaluated. The following table summarizes the results of economic and financial analysis:

Table 3 Summary of Economic and Financial Analyses of Pre-FS Schemes

No.	Scheme	Phase	EIRR	Assumed Tariff (\$/kWh)	FIRR	Subsidy	GHG* (t-CO ₂)	Annual Supply (MWh)
1	Samlout	Phase 1	27.4%	0.335	5.6%	25%	9,912	298.1
2	Bu Sra		12.6%	0.160	7.1%	50%	5,900	228.0
3	Pramaoy	Phase 1	33.3%	0.400	5.0%	25%	1,432	42.6
4-3	Samraong	Plan 3	37.3%	0.270	4.9%	25%	5,238	157.2
5-1	Kampong Kor	Phase 1	30.9%	0.350	5.2%	25%	9,525	285.3
6	Srae Ta Pan			0.447	12.2%	90%	-	-

* Greenhouse gas emission effect: 1.3 kg-CO₂/kWh (1997 IPCC Guidelines)

(Source: JICA Study Team)

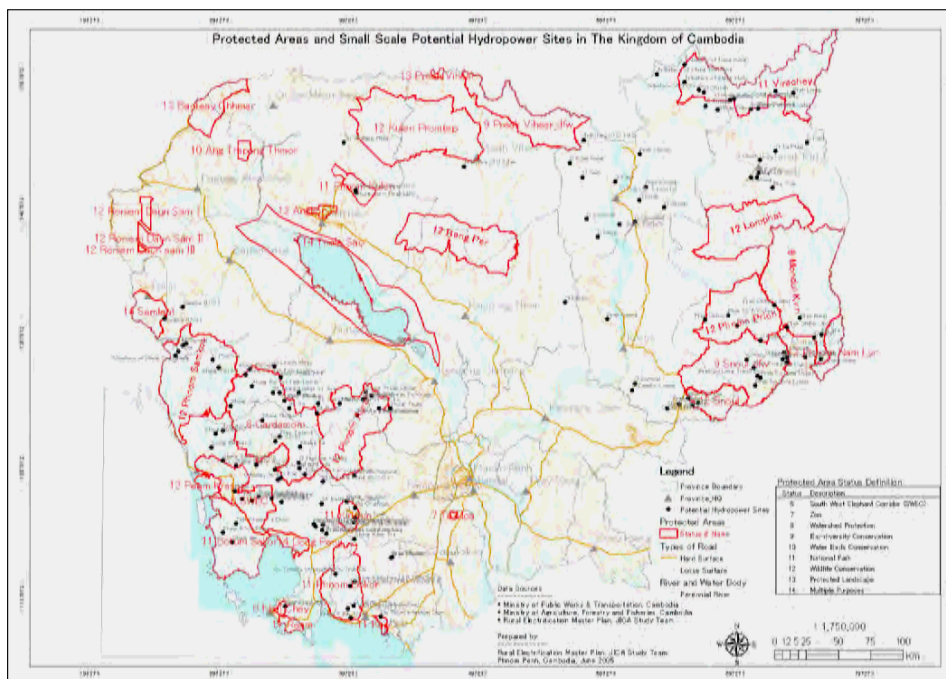
5. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

5.1 Necessity of EIA

According to the standard of Cambodia for Environmental Impact Assessment (EIA), it is required to conduct EIA for micro hydro when its installed capacity exceeds 1 MW and for thermal power (diesel, biomass) when it exceeds 5 MW. The scale of micro hydro and biomass power required for the six schemes are smaller than 1 MW, and thus EIA is not required.

5.2 Considerations for MHP

In Cambodia, environment-protected areas are defined as shown in Figure 2. Those micro hydro mini-grid schemes situated inside the protected areas (Bu Sra Scheme etc.) require environmental screening. In addition, according to the environmental and social consideration guidelines of JICA, those areas, where minority people living keeping their traditional ways of lives, are categorized as "Sensitive Area." Bu Sra Commune in Mondul Kiri Province is a village where most of the population is minority people. Special consideration are required to their ways of living when formulating such development plans.



Source: JICA study team

Figure 2 Micro Hydro Potentials and Environment Protected Areas

5.3 Consideration on BGP

It is regarded that biomass power does not have any special effect to the forestry because 1) fuel wood is supplied through fast growing tree farming; 2) when using community forests as fuel sources, cooperation and coordination with the Department of Forestry Administration and forestry NGO is arranged as a must; 3) when using agricultural wastes, it is planned only if fuel can be supplied without conflicts with existing users; 4) procurement of fuel wood from markets should be prohibited.

5.4 Considerations for Solar BCS

For solar BCS and SHS, treatment of waste battery will be an issue. In Cambodia, there are several battery collectors and recyclers on a commercial basis. However, their actual performance is yet to be known. This is one of the MIME’s policy issues.

6. CONCLUSIONS AND RECOMMENDATIONS

(1) Feasibility

Out of three micro hydro power schemes, Pramaoy scheme has insufficient river discharge. As a result of alternatives comparison, it is judged that electrification by biomass only is economically efficient. All schemes are planned to be operated by CEC¹. After pre-FS, pilot projects are to be implemented. As for

¹ Phase 1 of Samlout and Kampong Kor becomes a part of wide area mini-grid. In phase 2, RPC will be in charge of generation and transmission, and CEC will be in charge of distribution. Therefore, it is desirable to invite RPC through public participation from initial stage.

biomass, its technical issues are to be verified. In addition, it is a common issue to verify CEC's ability in operation and maintenance, and management of electrification business, irrespective of sources of energy.

(2) Implementation by CEC

For design and construction of Bu Sra scheme and Samlout scheme phase 1, it is difficult for CEC to be a main implementation body. It is recommended that implementation body should be MIME under semi-force account system. After construction completed, CEC will undertake operation and maintenance of facilities and business management as well. For four biomass schemes and one solar BCS scheme, it is judged that CEC/RPC can be a main implementation body with assistance to CEC from DIME and NGOs. However, it is quite important all the projects should have community workshop aiming at implementation, in the next study and planning stage, to explain and discuss about contents of schemes, initial investment cost and tariff levels etc., to obtain sufficient understandings and consent.

7. GENERAL ITEMS APPLIED TO PRE-FEASIBILITY STUDY

7.1 UNIT PRICE APPLIED TO COST ESTIMATE

As to unit prices for cost estimate of pre-feasibility studies, items and prices were assumed based on collected data, interview results of suppliers and contractors, as well as reflecting the past construction projects. Assumed unit price tables are as shown in Volume 5, Appendix-I.

PRE-FEASIBILITY STUDY

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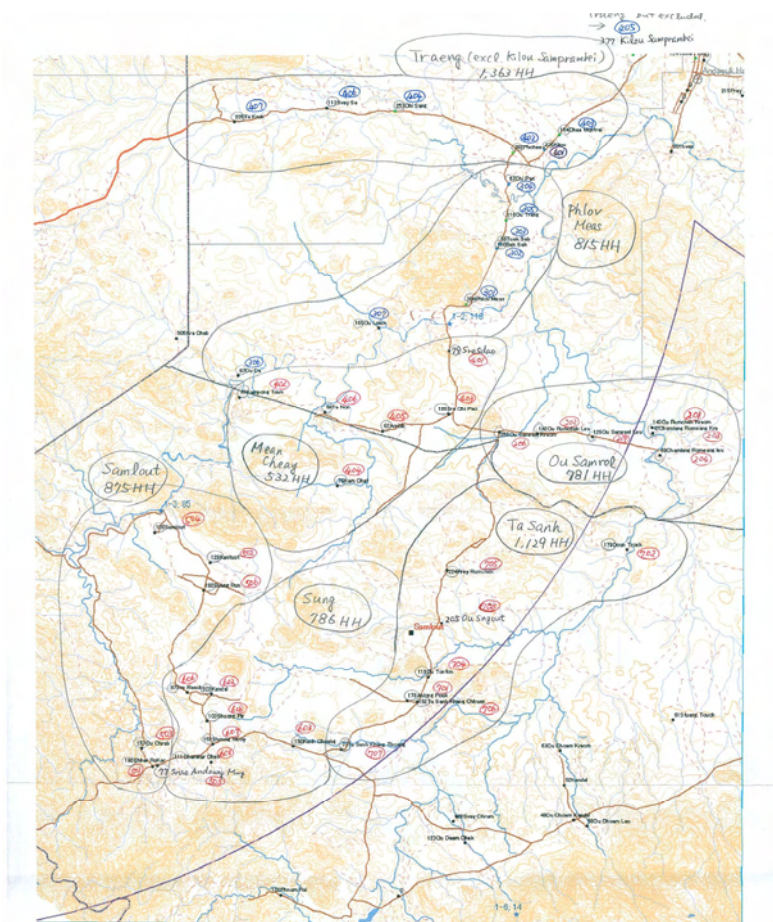
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PART 2 SAMLOUT ELECTRIFICATION PLAN

1. LOCATION AND FEATURES OF PLAN

Target area of Samlout Electrification Plan covers Samlout District and southern part of Rotanak Mondol District, consisting of 7 communes (Refer to Figure 2.1 Commune Name and Total Household Number of Target Area for Samlout Electrification Plan). More than 6,000 households are living in the area extended 25 km east and west, 30 km north and south. By assuming nationwide average of five (5) persons per household, population density is estimated to be two-third (2/3) of national average. Though there is not dense population as city areas, many households are distributed along the trunk road, which is appropriate for mini-grid electrification (Refer to Figure 2.2 Household Distributions in Samlout Electrification Area (by Handy GPS Survey)).

Micro hydro power potential was identified in the upstream part of Sangke River flowing from southwest to northeast of the province.



(Prepared by JICA Study Team)

Figure 2.1 Commune Name and Total Household Number of Target Area for Samlout Electrification Scheme

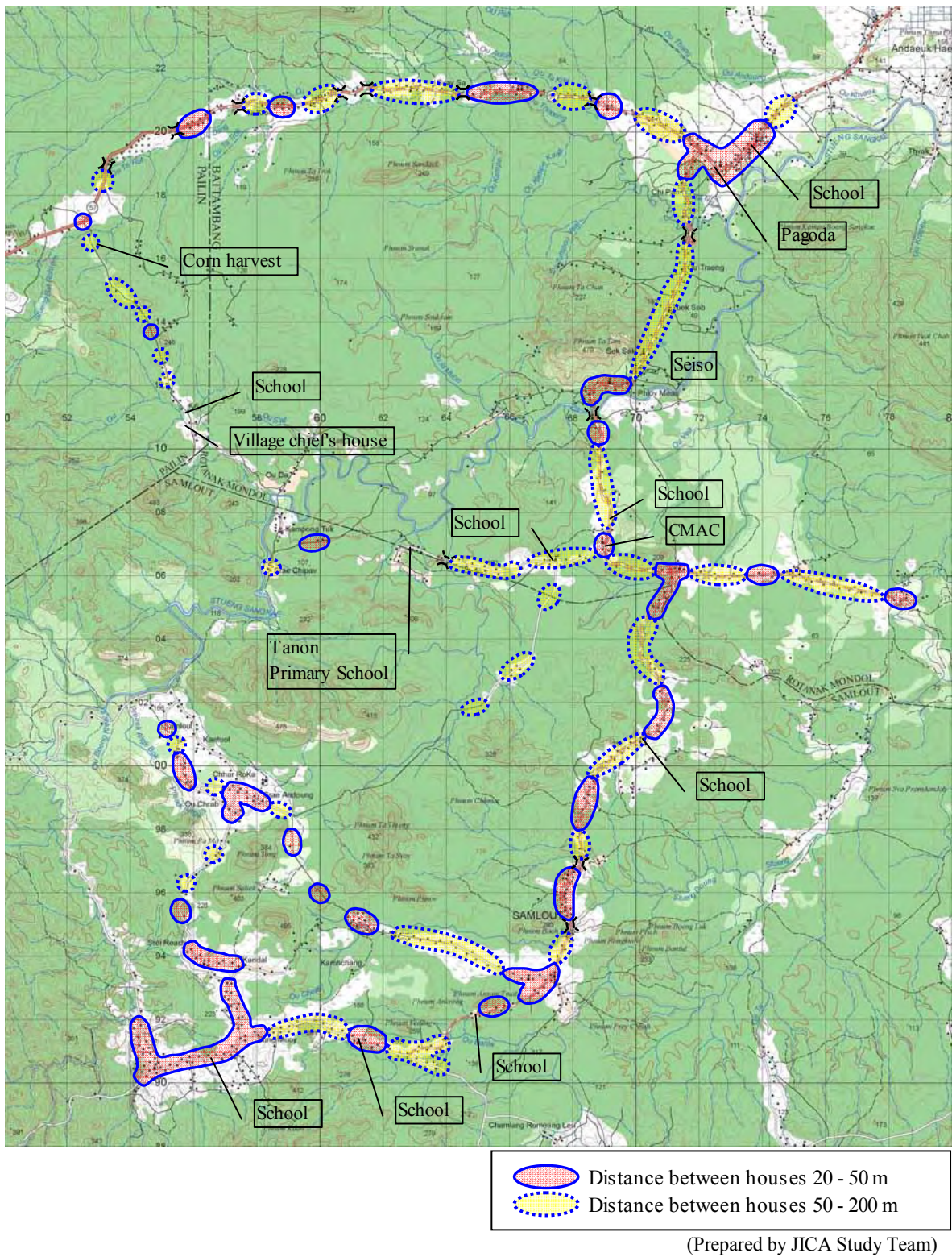


Figure 2.2 Household Distributions in Samlout Electrification Area (by Handy GPS Survey)