No.

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 3: MANUALS

June 2006

Japan International Cooperation Agency

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

ED
JR
06-078

Japan International Cooperation Agency

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 3 : MANUALS

June 2006

NIPPON KOEI CO., LTD., Tokyo

KRI INTERNATIONAL CORP., Tokyo

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.

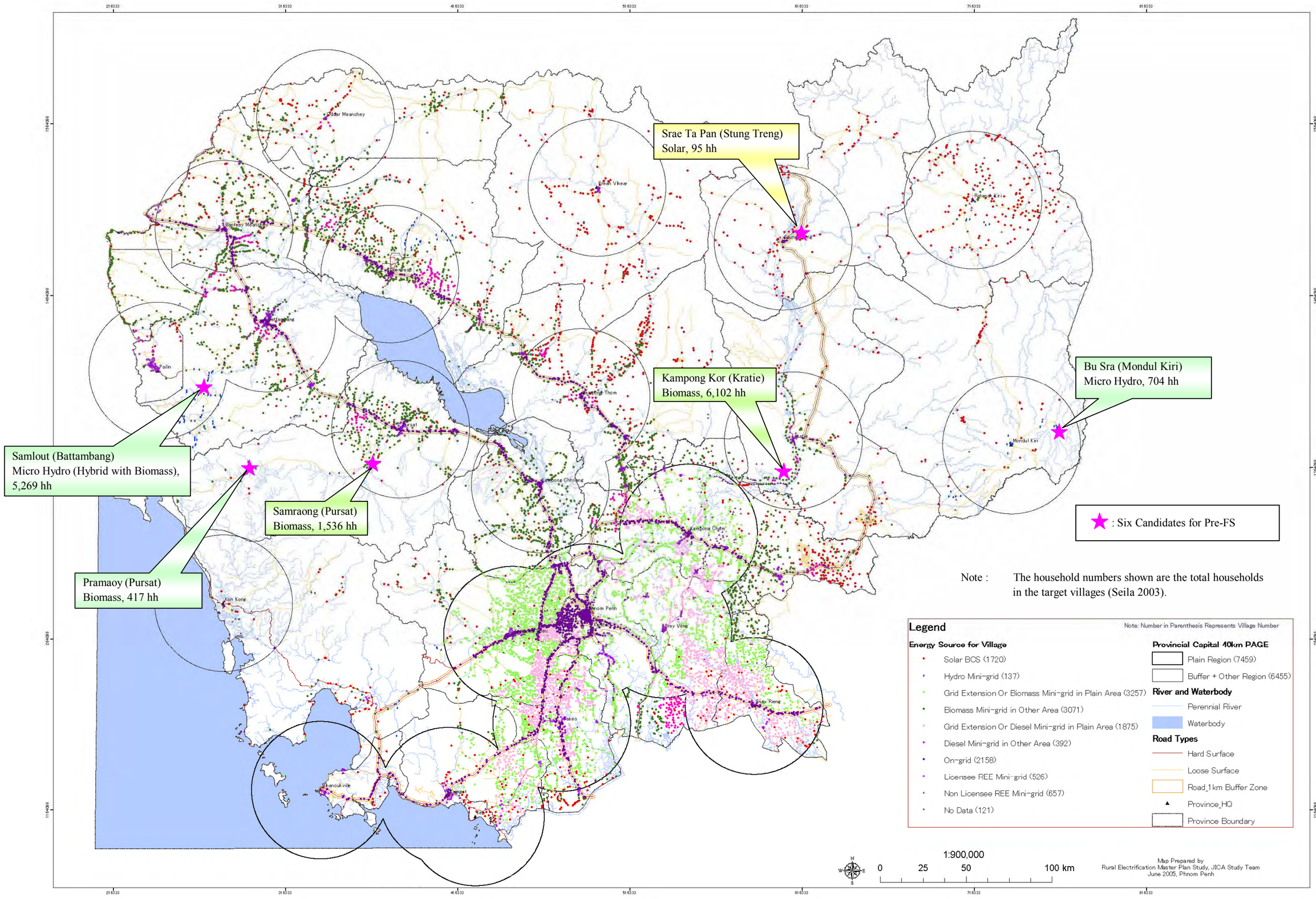
In order to promote awareness and understanding of the private/community driven electrification projects in the off-grid areas, we have - in addition to the Final Report - prepared a visual guide to serve as an illustrated version of the electrification manual. The Visual Guide is in Khmer and English. 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



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
MDG	Millennium Development Goals

Abbreviation	Description
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

MANUALS

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

Volume 3 Manuals

Part 1	**Manual for Updating Master Plan**
Part 2	**Manual for Preparation of Electrification Plan**

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

FINAL REPORT
VOLUME 3 : MANUALS

Table of Contents

PART 1 MANUAL FOR UPDATING MASTER PLAN P1-1

1. INTRODUCTION P1-1
   1.1 WHAT SHOULD BE REVIEWED/UPDATED P1-1
   1.2 WHO SHOULD UPDATE AND WHAT IS THE INTERVAL P1-1
2. HOW TO UPDATE MASTER PLAN P1-2
   2.1 LEVEL OF RURAL ELECTRIFICATION ACHIEVED P1-2
   2.2 EXTENSION PLAN OF EDC GRID P1-2
   2.3 DEFINITION OF OFF-GRID AREA P1-3
   2.4 VILLAGE ELECTRIFICATION PLAN P1-6
      2.4.1 Staged Electrification P1-6
      2.4.2 Selection of Energy Source Most Suitable for Each Village P1-7
      2.4.3 Unit Demand for Rural Electrification in Off-grid Areas P1-13
      2.4.4 Planning of Village Electrification P1-13
   2.5 PRIORITY RANKING FOR IMPLEMENTATION P1-19
      2.5.1 Ranking Criteria of Priority Schemes P1-19
      2.5.2 Ranking of RE Schemes with Excel P1-25
   2.6 IMPLEMENTATION PROGRAM P1-26
      2.6.1 Phased Implementation Schedule P1-26
      2.6.2 Funding Schedule P1-26
3. HOW TO UPDATE GIS DATABASE P1-29
   3.1 INTRODUCTION P1-29
   3.2 VILLAGE ENERGY SOURCE SELECTION P1-29
      3.2.1 GIS Data Preparation P1-30
      3.2.2 Model Implementation P1-31
      3.2.3 Focal Data Updating Points and Its Sources P1-34
   3.3 UPDATING GIS DATABASE P1-34
      3.3.1 Planning and Design of Database P1-35
      3.3.2 Structure of the Database P1-35
      3.3.3 GIS Software P1-36
      3.3.4 Time Frame of Database Upgrading P1-36
      3.3.5 Feature to be Updated P1-37
      3.3.6 Illustrative Method of Updating Database P1-38
      3.3.7 Map Projection System P1-41
      3.3.8 Data Sharing and Copyright P1-44
      3.3.9 Some Important Dataset that Need Urgent/Timely Attention for Updating P1-44
   3.4 CONCLUSION P1-45
4. PUBLIC RELATIONS P1-46

List of Tables

Table 2.1.1 Sample Form for Village Survey on Electrification P1-2
Table 2.3.1 Nos. of Villages, Families and Population inside PAGE P1-4
Table 2.4.1 Strategy of Three Staged Electrification P1-6
Table 2.4.2 List of Villages and Households by Source of Energy P1-9
Table 2.4.3 Status of identified and planned micro hydro schemes for village electrification P1-14
Table 2.4.4 Summary of Installed Capacity and Construction Costs P1-15
Table 2.4.5 Constants for Planning of Electrification Plan P1-16
Table 2.4.6 Form for Planning and Ranking of Mini-Grids by Micro Hydro P1-17
Table 2.4.7 Form for Planning and Ranking of Mini-Grids by Biomass Gasification Power P1-18
Table 2.4.8 Form for Planning and Ranking of Solar BCS and PV Systems for Public Facilities P1-18
Table 2.5.1 Grouping of Villages by Source of Energy with GIS Database P1-19
Table 2.5.2 Ranking of Solar BCS and PV Systems for Public Facilities P1-23
Table 2.5.3 Ranking of Mini-grids P1-24
Table 2.5.4 Number of RE Schemes by Type, MP 2005 ..... P1-25
Table 2.6.1 Phased Implementation Schedule P1-26
Table 2.6.2 Phased Investment Plan by Electrification Type P1-27
Table 2.6.3 Phased Investment Plan by Fund Sources P1-27
Table 2.6.4 Funding Schedule and Indicative Funding Sources P1-28

List of Figures

Figure 2.3.1 Potential Area of Grid Extension (PAGE), On-Grid Area, and Off-Grid Area P1-4
Figure 2.3.2 Sample Village Map (1/2) P1-5
Figure 2.3.2 Sample Village Map (2/2) P1-6
Figure 2.4.1 Source of Energy for Villages in Off-Grid Area, Master Plan 2005 ..... P1-8
Figure 2.4.2 Flowchart Used in Selecting Source of Energy and Type of Supply for MP2005 ..... P1-11
Figure 2.4.3 Flowchart for Updating Source of Energy and Type of Supply P1-12
Figure 2.5.1 Flowchart for Selection of Priority Schemes P1-20
Figure 2.5.2 Parameters and Weights for Ranking of RE Schemes with Mini-Grids P1-21
Figure 2.5.3 Parameters and Weights for Ranking of RE Schemes with Solar BCS P1-21
Figure 2.5.4 Sources of Energy and Type of RE by Village, MP2005 ..... P1-25
Figure 3.3.1 Layout of GIS Database at JICA Study Team Server P1-35
Figure 3.3.2 Starting Edit Session P1-38
Figure 3.3.3 Selecting Dataset Folder P1-38
Figure 3.3.4 Selecting Target, Task and Appropriate Editing Tool P1-39
Figure 3.3.5 Adding New Village in the Dataset P1-39
Figure 3.3.6 Opening Attribute Table of Dataset P1-40
Figure 3.3.7 Attribute Table in Edit Mode P1-40
Figure 3.3.8 Selecting Items Using Data Query P1-40
Figure 3.3.9 Selected Column for Calculating Attribute P1-41
Figure 3.3.10 Calculating Character and Numerical Attributes P1-41
Figure 3.3.11 ArcToolbox Popup Window after Selecting ArcTool from Main Menu P1-42
Figure 3.3.12 Popup Window for Defining Dataset Projection P1-42
Figure 3.3.13 Map Reprojection Main Window P1-43
Figure 3.3.14 Options for Selecting New Coordinate System P1-43

HOW TO USE THE MANUAL

Who are the Manual for?

The Manual for updating the Master Plan for Rural Electrification (MP) aims at serving those staff of the Department of Energy Technique, MIME in reviewing and updating MP.

What is the purpose of the Manual?

The Manual provide basic information and criteria to facilitate updating MP.

Are there any other references?

As part of the MP, there is another Manual for Rural Electrification by Renewable Energy. It covers *Remote Electrification* by solar BCS, *Social Electrification* by SHS, and mini-grids by biomass gasification power and micro hydro. It explains:

- What is the Government policy to achieve the national electrification targets?
- When is the national grid expected to come to villages?
- What is rural electrification in the off-grid areas?
- What are the options available for the villagers in the off-grid areas to achieve electrification of own villages?
- What is renewable energy?
- What level of electrification can be achieved by renewable energy?
- What is the renewable energy most suitable for the village?
- How to estimate the potential of renewable energy?
- How to plan village electrification?
- What is the cost level?
- What kind of supports are available and who can support?
- What are the required preparatory works and procedures up to application for financial and technical supports?

Part 1 Manual for Updating Master Plan

1. INTRODUCTION

1.1 WHAT SHOULD BE REVIEWED/UPDATED

The following data and elements of the Master Plan shall be reviewed and updated in accordance with the procedures and method described hereinafter:

- Level of the rural electrification achieved by the previous year : it is proposed that the level of rural electrification be surveyed together with the annually conducted village survey for Commune Database (CDB) under the Ministry of Planning.
- Extension plan of EdC grid (MIME and EdC);
- Off-grid areas;
- Demographic conditions of villages located in the off-grid areas;
- Plans of village electrification by commune /village councils;
- Unit prices of generating facilities and equipment and distribution lines;
- Priority ranking for implementation;
- Establishment of Commune / Village Electrification Committee (cooperatives)
- Implementation program with time and budget schedules (MEF, MIME, EdC).

1.2 WHO SHOULD UPDATE AND WHAT IS THE INTERVAL

The Department of Energy Technique of MIME shall be responsible in monitoring, reviewing and updating the Master Plan. The implementation progress of the Master Plan shall be monitored every year based on the village database, the national information system of the General Directorate of Planning in the Ministry of Planning [1].The survey will be conducted every December and the results compiled and available in June following year.

The Master Plan shall be updated every four year with the RE periods defined as follows:

1st RE Program: 2005-2008

2nd RE Program: 2009-2012

3rd RE Program: 2013-2016

4th RE Program: 2017-2020

[1] A commune database (CDB) is managed by the Provincial Departments of Planning under the technical supervision of the Ministry of Planning.

2. HOW TO UPDATE MASTER PLAN

2.1 LEVEL OF RURAL ELECTRIFICATION ACHIEVED

The achievement of the rural electrification sector shall be monitored every year through annually conducted village survey for Commune Database (CDB) under the Ministry of Planning. The survey should include the following (see Table 2.1.1 for a sample form):

Table 2.1.1 Sample Form for Village Survey on Electrification

V.GIS	Province	District	Commune	Village	Province	District	Commune	Village	Family in 2003	Total Family in Feb. 2005	Family Electrified by mini grids	Family Electrified by battery	Total Family Electrified	Family having TV	Number of BCS
កូដភូមិ	ខេត្ត	ស្រុក	ឃុំ	ភូមិ	ខេត្ត	ស្រុក	ឃុំ	ភូមិ	ចំនួនគ្រួសារសរុប	ចំនួនគ្រួសារសរុបក្នុងខែកុម្ភៈ ឆ្នាំ២០០៥	គ្រួសារដែលភ្ជាប់ផ្គត់ផ្គង់អគ្គិសនីដោយសហគ្រាសឯកជន	គ្រួសារដែលភ្ជាប់ផ្គត់ផ្គង់អគ្គិសនីដោយអាគុយ	គ្រួសារដែលភ្ជាប់ផ្គត់ផ្គង់អគ្គិសនី	គ្រួសារដែលមានទូរទស្សន៍	ចំនួនប្រព័ន្ធសាកអាគុយ
22010101	Otdar Meanchey	Anlong Veaeng	Anlong Veaeng	Kaoh Thmei	ឧត្តរមានជ័យ	អន្លង់វែង	អន្លង់វែង	ក្រោះថ្មី	51						
22010102	Otdar Meanchey	Anlong Veaeng	Anlong Veaeng	Ou Chenchien	ឧត្តរមានជ័យ	អន្លង់វែង	អន្លង់វែង	អូរចិនជ្រៀង	326						
22010103	Otdar Meanchey	Anlong Veaeng	Anlong Veaeng	Prolean	ឧត្តរមានជ័យ	អន្លង់វែង	អន្លង់វែង	ព្រលាន	158						

Source: Ministry of Planning

1) Number of households electrified by the National Grid, mini-grids, self-generators and similar;
2) Number of households electrified only with battery lighting excluding the households above;
3) Number of BCS within the village (if none, road distance in km to the nearest BCS); and
4) Number of TV sets in the villages as a representative parameter of demand to electrification and ability to pay.

The following data on the rural electrification shall be collected by the Energy Technique Department of MIME from respective agencies every year:

- A list of REE on those newly licensed and not extended by EAC, including registered map of concession area;
- A list of RE projects taken up and supported by REF; and

Maps shall be updated by the Energy Technique Department of MIME every year by inputting the data above into the RE Database 2005 on the following topics:

- Level of household electrification by the National Grid and mini-grids;
- Level of village electrification by BCS; and
- Overall level of village electrification both by grids and BCS.

2.2 EXTENSION PLAN OF EDC GRID

The following information on GIS database shall be collected from EdC by the Energy Technique Department of MIME every four year on the HV (220 kV and 115 kV) and MV (22 kV) lines of EdC and REE:

- Map showing routes of HV lines and GS (grid substation) existing, under implementation, and newly committed;
- Map showing routes of MV lines existing, under implementation, and newly committed; and
- Commissioning year of the above.

2.3 DEFINITION OF OFF-GRID AREA

(1) Potential Area of Grid Expansion (PAGE)

Figure 2.3.1 shows the Potential Area of Grid Expansion. Each circle has a radius of 40 km with center at provincial capital. The radius of 40 km is a technical limit of distribution lines extended from Grid Substation (GS). PAGE covers over 80% of both villages and households in Cambodia as shown in Table 2.3.1.

PAGE should be electrified both by the grid extension of EdC and by mini-grids of REE and CBO (to be complemented by solar BCS). Those outside PAGE should be electrified by mini-grids and solar BCS as well as additional extension of the National Grid.

(2) National Grid and On-Grid Area

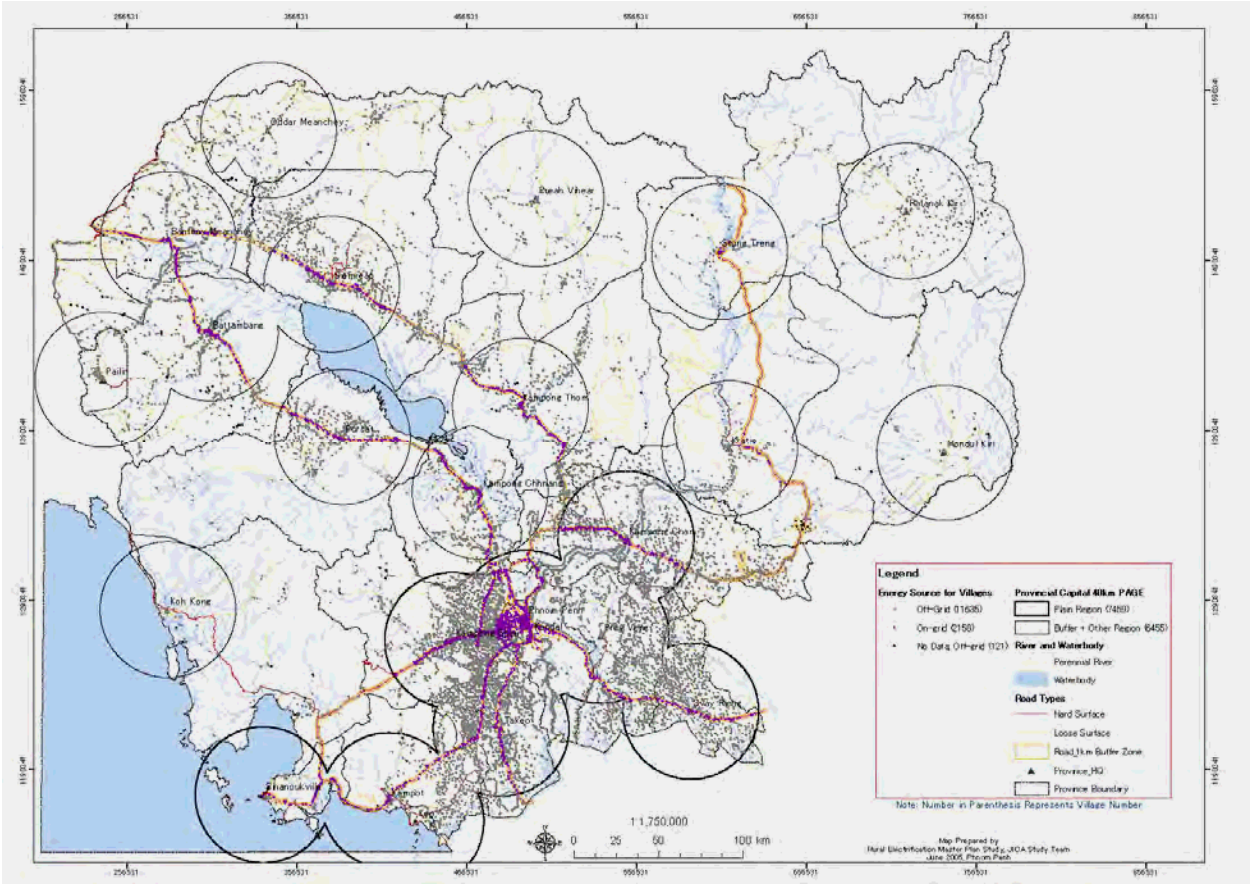
The National Grid is defined as the HV transmission grid of EdC and those owned by others connected to the EdC grid, as well as MV lines extended from the HV grid to outside the EdC supply area to connect to distribution sub-grids owned by licensed REEs. An extension plan of the National Grid will be studied and prepared within the Potential Area of Grid Expansion in principle.

The On-Grid Area is defined as those that are supplied by the National Grid including MV and LV distribution lines of REE/CBO that have been connected to the National Grid. As of June 2005, the On-Grid Area is only the Phnom Penh grid of EdC.

The future grid extension will be given priority to, among others, those villages located along the so-called “one digit national roads” such as Route #1 (Prey Veng and Svay Rieng), #2 (Takeo), #3 (Kampot), $4 (Kampong Speu, Sihanoukville), #5 (Kampong Chhnang, Pursat, Battambang, Banteay Meanchey), #6 (Kampong Cham, Kampong Thum, Siemreap), and #7 (Kampong Cham, and so on). These priority areas are shown in Figure 2.3.1 as purple dots along the roads.

(3) Off-Grid Area

The Off-Grid Area as the target area of the Master Plan is defined as the whole country area less the On-Grid Area. The Off-Grid Area is shown as grey dots in Figure 2.3.1. It may be noted that the On-Grid Area will gradually expand from year to year while the Off-Grid Area will shrink along with the grid extension.



Source: JICA Study Team

Figure 2.3.1 Potential Area of Grid Extension (PAGE), On-Grid Area, and Off-Grid Area

Table 2.3.1 Nos. of Villages, Families and Population inside PAGE

ID No.	Province	Nos. inside 40 km Circle		
		Village	Family	Population
1	Banteay Meanchey	497	97,241	497,539
2	Battambang	420	116,584	603,178
3	Kampong Cham	1,108	222,128	1,059,367
4	Kampong Chhnang	519	89,461	432,664
5	Kampong Speu	1,322	119,061	628,664
6	Kampong Thom	392	66,393	343,356
7/23	Kampot/Kep	288	70,546	365,472
9	Koh Kong	36	9,281	48,375
10	Kratie	200	52,594	260,671
11	Mondul Kiri	53	5,153	22,438
8/12	Phnom Penh/Kandal	1,833	394,041	2,063,825
13	Preah Vihear	98	13,619	68,600
14	Prey Veng	859	180,013	855,418
15	Pursat	477	72,256	373,633
16	Ratanak Kiri	205	19,887	97,275
17	Siemreap	497	86,599	247,787
18	Sihanoukville	80	28,141	148,500
19	Stung Treng	83	12,544	65,969
20	Svay Rieng	740	124,664	600,719
21	Takeo	1,333	223,877	1,152,630
22	Oddar Meanchey	175	20,206	106,145
24	Pailin	175	23,439	109,783
	Total within the 40 km circles	11,390	2,047,728	10,152,008
	(%)	82.61%	83.34%	81.62%
Total of Country		13,787	2,457,074	12,438,121

Source: JICA Study Team

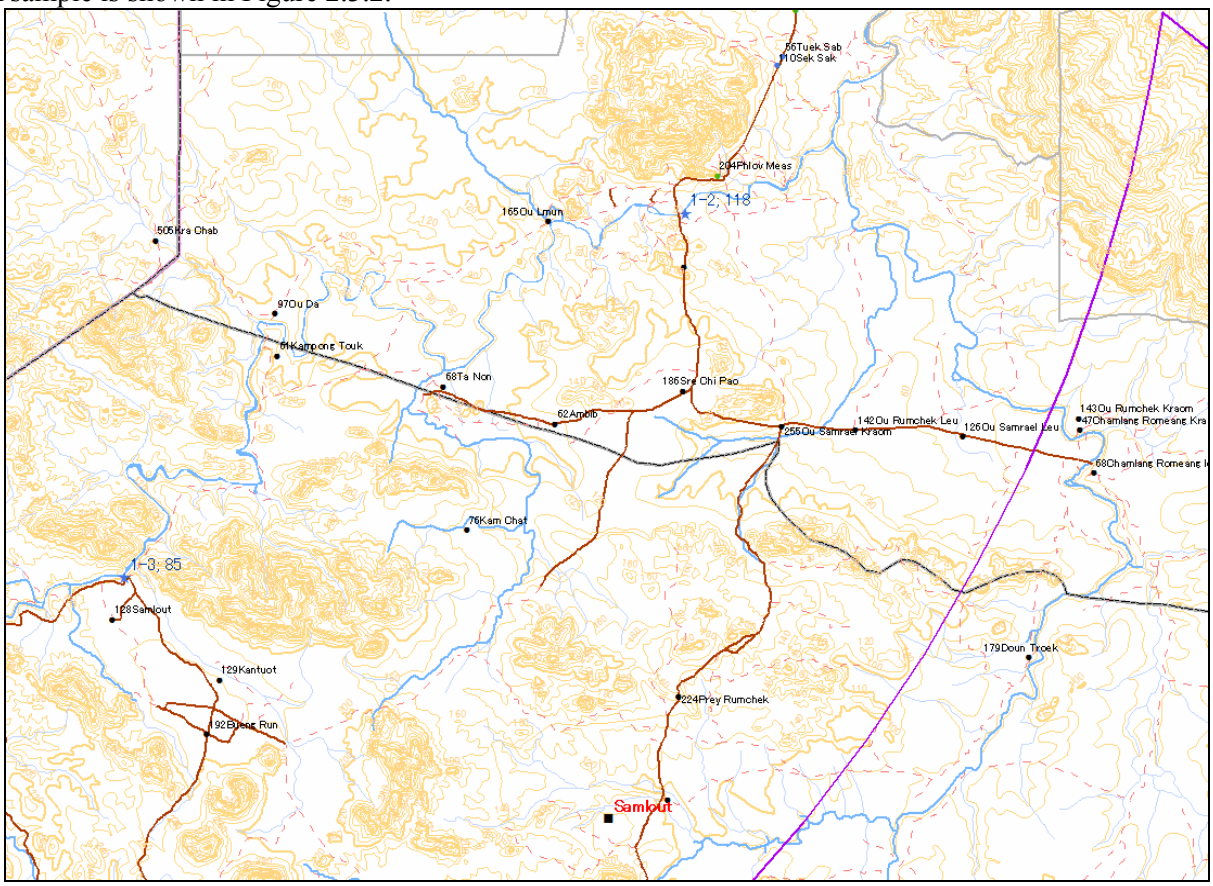
The off-grid areas then can be defined as:

1) areas located outside the 40 km circular areas from each provincial capital;

2) areas located within the 40 km circular areas from each provincial capital but excluding the following:

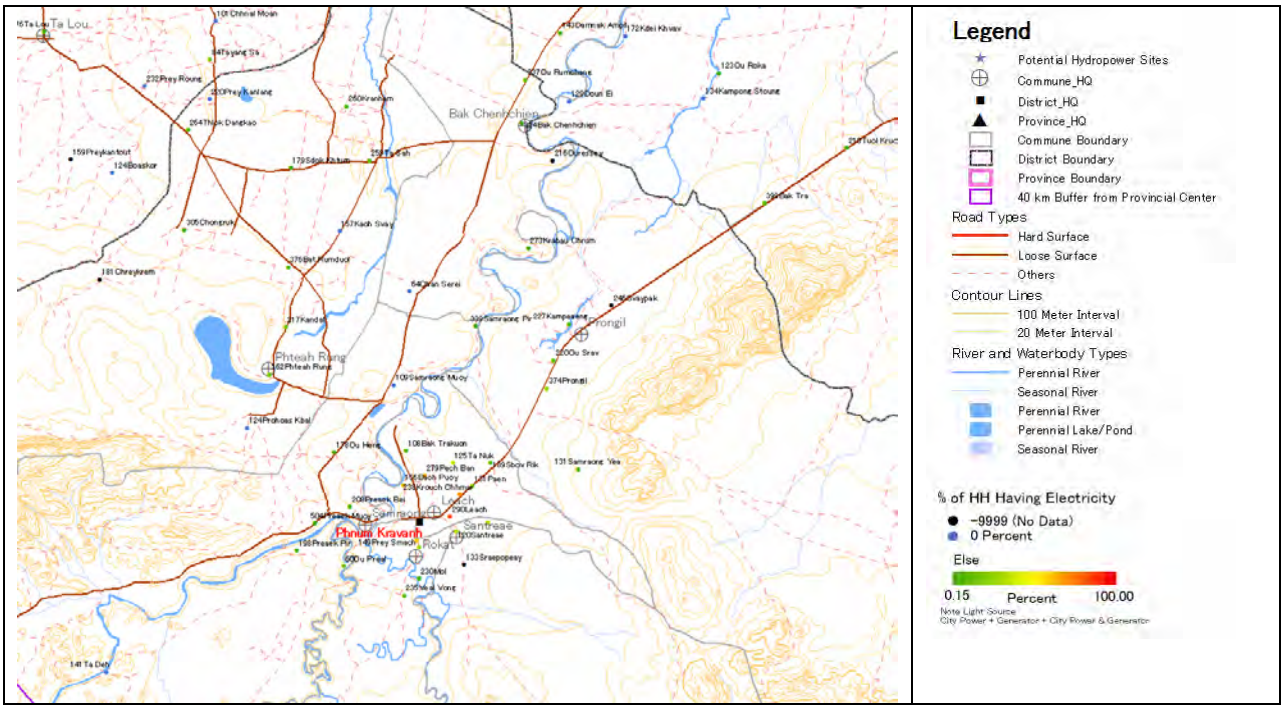
   - areas supplied by the National Grid or existing REE;
   - areas of 1 km distance from the one digit national roads on both sides.

Based on these information, the Map of Off-grid Areas shall be updated to replace Figure 2.3.1 as of 2004. Maps of villages in the updated off-grid areas shall be prepared at a scale of 1:100,000 (89 sheets in total). A sample is shown in Figure 2.3.2.



Source: JICA Study Team
Battambang Province, Ratanak Mondul and Samlout Districts, Scheme: Sangke River Micro Hydro & Biomass Hybrid

Figure 2.3.2 Sample Village Map (1/2)



Source: JICA Study Team
Province, Phum Kravanh District, Scheme: Phm Kravanh Biomass

Figure 2.3.2 Sample Village Map (2/2)

2.4 VILLAGE ELECTRIFICATION PLAN

2.4.1 Staged Electrification

It is recommended in the Master Plan that the rural electrification in the off-grid areas be achieved in the following three stages:

Table 2.4.1 Strategy of Three Staged Electrification

RE Stage	Media	Source of Energy	Use of Electricity	Power Consumption Level per Household	Tariff Level in $/kWh	
					in 2005	Target of MP
1	Battery	Solar power (PV panels at BCS or public facilities)	Home lighting, optionally TV Health post, night school, community hall	10 W 40 W with TV 3.3 kWh per month	1.02 including battery cost 0.38 per charging	0.56 including battery cost 0.10 per charging
2	Mini-grids	Biomass gasification power, Micro hydro	Home lighting, TV, other light load appliances Streetlights, public facilities, commercial Handicraft industry, BCS, water pumps, etc.	100 W on average (30-200 W) 5-15 kWh per month	0.30-0.91	0.35
3	National grid	Diesel, Imported power, Hydro, etc.	any kind of domestic uses industry, commerce, etc.	as much power as needed 50 kWh per month in 2004	0.09-0.15	0.10

Source: JICA Study Team

Each stage is featured by:

Electrification Stage 1: This is to promote battery lighting to achieve the target level 100% of village electrification by 2020. The present high tariff of battery lighting at $0.38 per time can be lowered to below US$0.17/kWh with solar BCS if installed with 100% grant and operated by villagers. However, users still need to buy batteries by themselves.

Electrification Stage 2: This to electrify, by mini-grids, those villages where battery lighting has been diffused at higher than 50%. The mini-grids, combined with grid extension, are the main vehicle towards another target level 70% of household electrification by 2030. In the mini-grids however, use of such heavy load appliances should be refrained as electric iron, cooking stove, water heater. Those people, who can afford to buy such heavy loading appliances and wish to use, should wait until the grid connection or introduce own self-generator. As for the tariff level, it is the target of the Master Plan to lower to $0.35/kWh with financial subsidy to the initial capital costs. This tariff level is still high because of very low plant factor of around 10%, which represent such RE situation in 2005 as monthly consumption at about 10 kWh per household with peak load at 100 W and peak capacity requirement at 130 W including loss and reserve at 30% (10 kWh / (24 hours x 30 days) / (0.1 kW x 130%) = 10.7%).

Electrification Stage 3: This is the ultimate stage of rural electrification by the National Grid, where people can use as many appliances as they wish to use with stable and 24 hour supply at the lowest tariff. The area is referred to as the On-Grid Area with a backbone of the National Grid of EdC. The mid-term price target is set at $0.10/kWh after commencing bulk import of low cost energy both from Thai and Vietnam.

2.4.2 Selection of Energy Source Most Suitable for Each Village

Sources of energy and type of supply selected for each village under the Master Plan 2005 are presented in Figure 2.4.1. It is recommended in the Master Plan that the following four sources of energy combined with two types of supply (BCS or mini-grids) be employed for rural electrification in the off-grid areas:

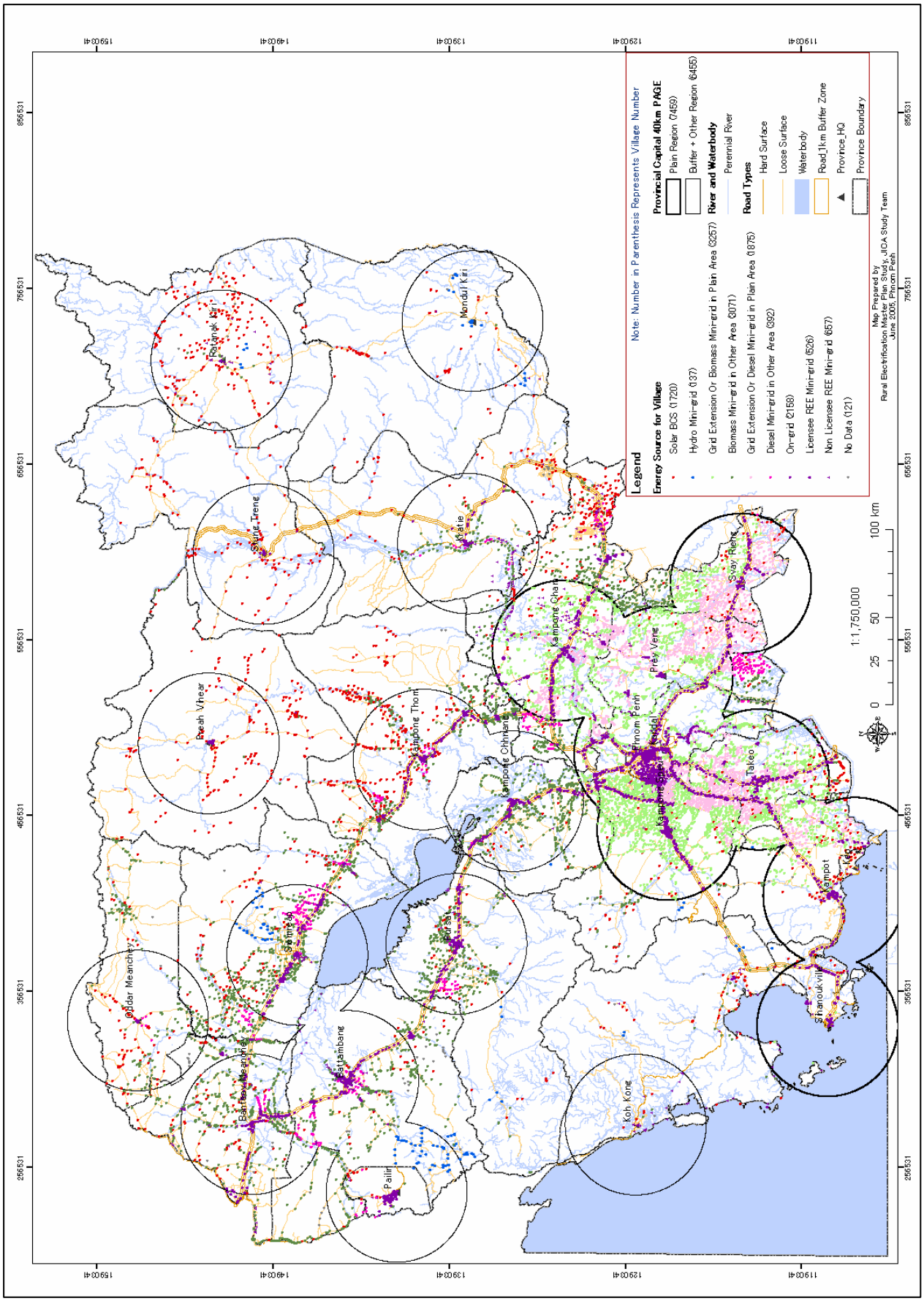
1) Solar BCS for battery lighting at 10 W. Optionally TV can be introduced at about 30 W by those who can afford to buy. The unit cost of electricity for battery lighting is about $1.02/kWh in 2004 including battery costs. This would be lowered to about US$0.56/kWh with solar BCS if installed with 90% grant and operated by villagers. The solar power includes the following three types of applications:

   - battery charging station (BCS) for promoting electrification of remote villages (*remote electrification*);
   - PV systems for promoting electrification of public facilities (*social electrification*);
   - SHS for individual households who can afford to introduce on commercial basis from the market with subsidy (25% grant) from REF to suppliers.

2) Mini-grid by micro hydro to supply about 100 W per household for lighting, TV, and similar electric appliances of low-power consumption. The standard capacity of one generating unit applicable to rural electrification in Cambodia may be from 10 kW to 200 kW class in continuous output basis.

3) Mini-grid by biomass gasification power for the same uses and capacity as of micro hydro above. The capacity can be expanded by installing multiple units of generator. The minimum area of required land (grassland and shrubland including fallow land) is 0.02 ha per household assuming annual production of 10 dry ton of fuel wood per ha.

4) Diesel mini-grids as alternative to biomass mini-grids above when there is no land sufficient to grow fuel trees. These villages are shown as pink color in Figure 2.4.1.



Source: JICA Study Team

Figure 2.4.1 Source of Energy for Villages in Off-Grid Area, Master Plan 2005

For each village, the source of renewable energy shall first be updated with GIS from among the four options above in accordance with a flowchart presented in Figure 2.4.3. In preparing the Master Plan 2005, a flowchart shown in Figure 2.4.2 was used because of the limited village data.

As baseline data for updating the Master Plan, results of energy source selection made in the Master Plan 2005 are summarized in Table 2.4.2.

Table 2.4.2 List of Villages and Households by Source of Energy

Main Target Areas	Energy Sources	Number of Target Villages	Number of Target Households
Electrified area	EdC Grid	1,405	313,387
	Isolated diesel mini-grids by REE	526	153,350
	Isolated mini diesel grid by REE with imported electricity		
	Isolated mini diesel grid by non-registered REE	657	156,786
	The private diesel BCS	n.a.	n.a.
	Sub-total	2,588	623,523
New electrified area			
On-Grid Area	Grid extension	753	208,520
Northeast or North provinces	Solar	1,720	237,570
Northeast, Southwest and mountainous areas	Micro hydro	137	18,541
	Hybrid (Micro hydro + Biomass gassification)		
Tonle Sap Coast	Biomass gasification	3,071	501,636
	Diesel	392	69,390
Central plain areas	Grid extension or biomass gasification	3,257	504,397
	Grid extension or diesel gasification	1,875	294,374
Total number of new electrified villages		11,205	1,834,428
Number of villages without detailed data		121	n.a.
Total		13,914	2,457,951

Note: The list of the Electrification Plan each village is attached with the other file. The total number of villages is 13,914, because the new four villages are added to the number shown in the Seila database 2003.
Source: JICA Study Team

Figure 2.4.2 was used for selection of priority schemes in the Master Plan 2005 under the limited availability on the village electrification data. Accordingly, the selection criteria employed the following assumptions in place of the accurate village electrification data:

1) For NIS database 1998: Is the level of electrification excluding battery >10%?

This judging condition assumes that the electrification level of > 10% in 1998 means:

i) the village has been electrified by grids;

ii) the level of grid electrification in 2004 is higher than the national average;

iii) these villages should continue to receive power supply by existing mini-grids of REE with extension of supply area, and should wait for the grid connection. It is an option for these villages to improve the supply situation (rehabilitation of distribution lines and conversion of diesel generators to biomass gasification power).

2) For Commune Database (CDB) 2003: Is the level of TV diffusion >10%

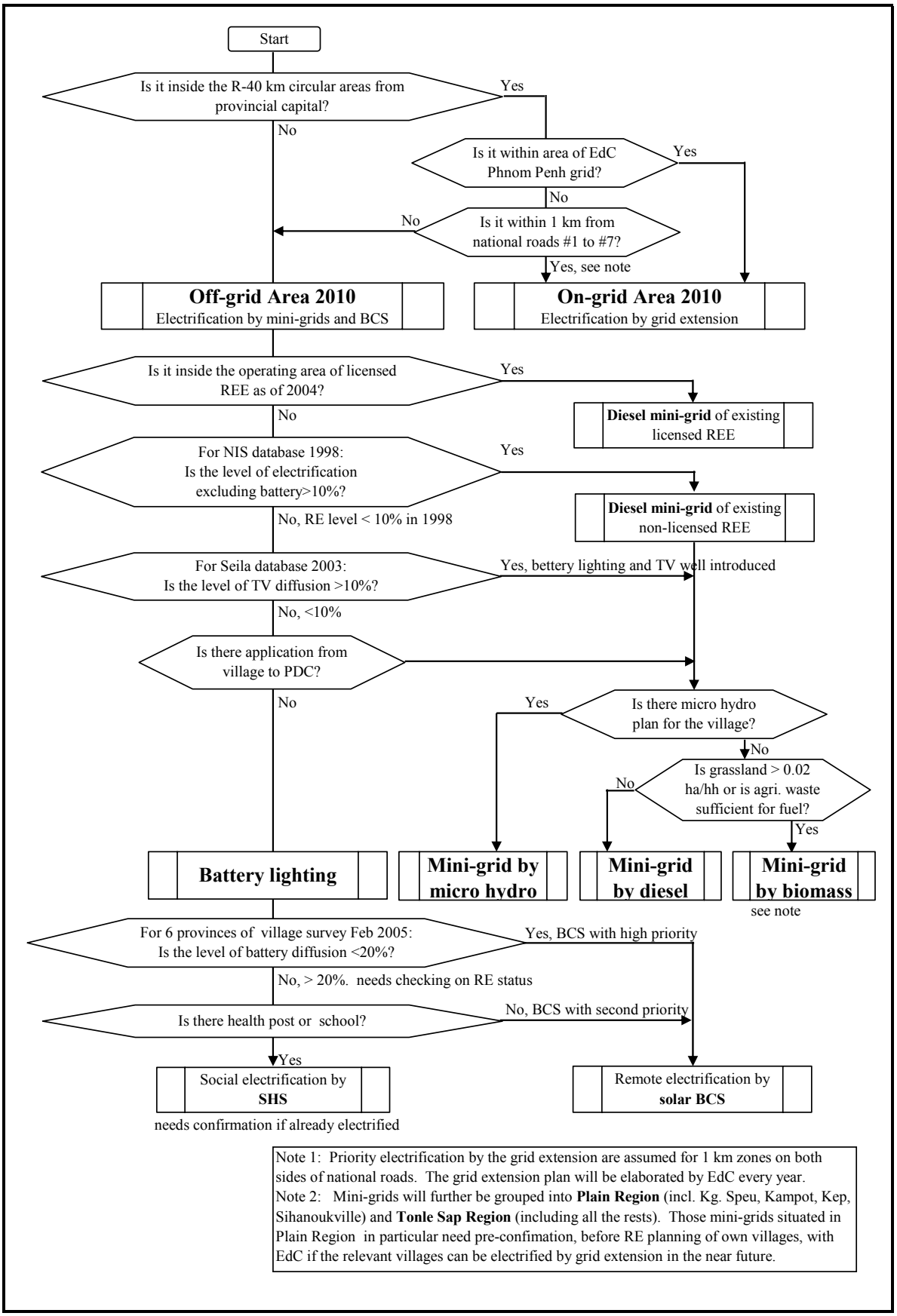
This judging condition was introduced as an additional index of the diffusion level of battery lighting since such data are available only in NIS database 1998, which has been clarified not applicable to the situation in 2003/04. Battery lighting has been introduced at a significant rate to make NIS database 1998 not dependable. On the other hand, CDB 2003 has no survey item on the battery lighting except for TV. Therefore, it is assumed that the TV diffusion level > 10% means the diffusion level of battery lighting be

already quite high, probably in excess of 50%.

These two judging conditions above can be replaced with the following single one when the latest village electrification data are made available through Seila village survey:

Is the diffusion level of battery electrification >50%?

The condition above is to test if the village electrification by battery has been matured and is ready to proceed to RE Stage 2 electrification by mini-grid. Actually, another criterion on Ability to Pay (ATP) may be added to secure sustainable management of the mini-grid as shown in Figure 2.4.3.



Source: JICA Study Team

Figure 2.4.2 Flowchart Used in Selecting Source of Energy and Type of Supply for MP2005

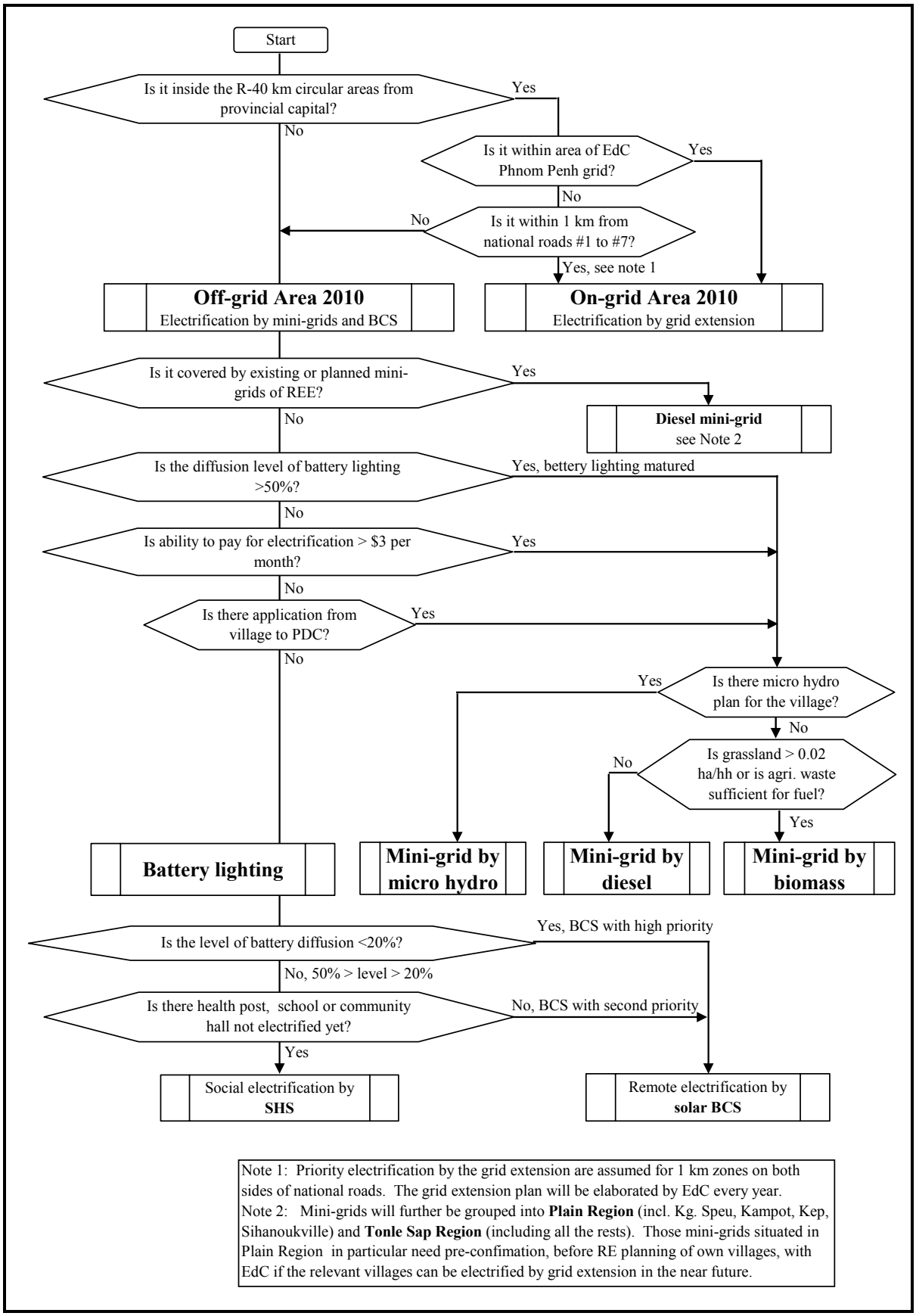


Figure 2.4.3 Flowchart for Updating Source of Energy and Type of Supply

2.4.3 Unit Demand for Rural Electrification in Off-grid Areas

(1) Domestic demand of mini-grids

It is a strategy and recommendation of the Master Plan that the electricity consumption per household under a mini-grid be limited to:

- lighting devices of 20 W x 3 nos. as standard;
- TV of 30-60 W class;
- other appliances of light load may be introduced to limited number of households in a village.

The average domestic demand in the rural areas is usually between 30 W and 200 W with average at about 100 W, depending on the level of household income. It is assumed in the MP2005 that the unit domestic demand to mini-grids be 100 W per household on an average.

In updating the Master Plan, the unit domestic demand should be reviewed based on the monitoring of new mini-grids. If there are power shortages claimed from users in some mini-grids, the unit domestic demand of 100 W should be reviewed based on case study of such power shortage cases. If it is judged the unit demand has increased along with socio-economic development in the off-grid area, then the unit demand should be updated and revised to a suitable level.

(2) Streetlights demand of mini-grids

The standard streetlight is 20 W fluorescent light (60 cm long), for each support of distribution lines. The standard number of streetlights per village is 30% of that of households in those villages located in the plain region (biomass or diesel mini-grids) and 80-100% in the hilly region (micro hydro mini-grids).

(3) Demand of public facilities to PV systems

The standard unit demand of public facilities is:

- 20 W fluorescent lights (60 cm long) or equivalent energy saving lamp per 2 m^2 in floor area for night school, to have 300 lx with lamp height at 1.85 m;
- - ditto - per 6 m^2 in floor area for health post, to have 100 lx with lamp height at 1.85 m;
- - ditto - per 6 m^2 in floor area for community hall.

2.4.4 Planning of Village Electrification

Conceptual electrification plan shall be updated for all the villages situated in the updated off-grid area. Because of the great number of villages, the planning shall be made on Excel sheets.

(1) Mini-grid by Micro Hydro

For mini-grid schemes by Micro Hydro, the following two items are required works for updating master plan.

1) Update of dry season discharge by newly or additional measurement

It is necessary to conduct dry season discharge measurement.

The reasons for the work are;

a) Dry season discharge is used to estimate firm output of a micro hydro scheme. Firm output is a possible generating capacity even during dry season.

b) In some schemes, actual discharge measurement has not made yet. For such schemes, dry season discharge is estimated using specific discharge in the region with the following equation.

$Q = q \times A$

Where; Q: dry season discharge (m^3/sec)

q: specific discharge estimated for the region (m^3/sec/km^2)

A: Catchment Area (km^2)

However, for formulation of more precise development plan of micro hydro, it is preferable to measure actual dry season discharge.

c) Even for schemes with discharge measurement, additional discharge measurement is preferable to accumulate dry season discharge data for planning.

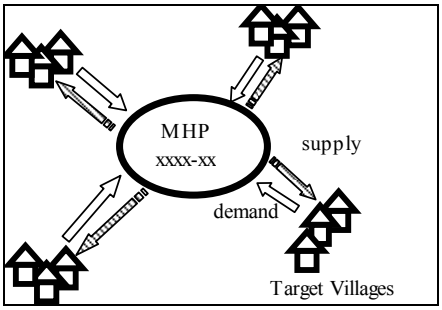
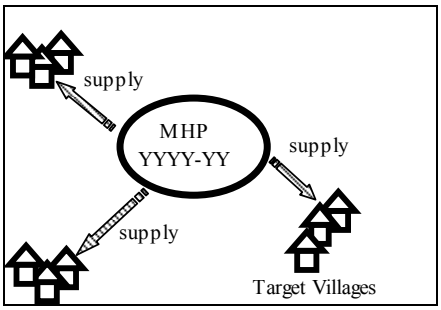
So far, out of 44 micro hydro schemes identified through map study (refer to Table 1.1.2a and Table 1.1.2b, Part3), discharge measurement was made for only 21 schemes.

Method of discharge measurement is given in section 5.1.5 of Part 4-2 (manual).

2) Update of electricity demand in the village

There are 44 micro hydro schemes so far identified covering 211 villages (refer to Table 1.1.2a and Table 1.1.2b, Part3). The following table summarizes breakdown of 44 micro hydro schemes.

Table 2.4.3 Status of identified and planned micro hydro schemes for village electrification

Schematic Diagram for Schemes and Villages	Nos. of schemes	Scheme Status	Village Status
	21 schemes	Ready for development to supply electricity to village.	137 villages in total, ready for micro hydro mini-grid installation in terms of demand and affordability. (Diffusion level of battery is more than 50%.)
	23 schemes	Ready for development to supply electricity to village.	74 villages in total, but still not ready for electrification by mini-grid in terms of demand and affordability. (Diffusion level of battery is less than 50%.) Classified into battery lighting group.
Total	44 schemes		211 villages

Source: JICA Study Team

Out of 44 schemes, 23 schemes have lower diffusion level of battery (less than 50%) in the target electrification villages (74 villages in total). This means that such villages are still premature for electrification by mini-grid. For this reason, such villages are so far classified into “Battery Lighting”

group according to flow chart in Figure 2.4.2. In the flow chart, diffusion level of battery is used as an indicator for mini-grid application.

However, from time to time, people in this target electrification area may become affordable to have battery for their lives. Therefore, at the time of update of master plan, it is necessary to check diffusion level of battery of target villages for the above 23 schemes.

Diffusion level of battery can be obtained from Seila database or relevant statistic sources. In case battery diffusion level becomes more than 50%, such target village can be classified into micro hydro group using flow chart shown in Figure 2.4.3.

In this connection, it is necessary to check battery diffusion level for villages which already have identified micro hydro scheme nearby.

As baseline data for reference in updating the Master Plan, installed capacity and draft estimate of construction costs are shown in Table 2.4.4.

Table 2.4.4 Summary of Installed Capacity and Construction Costs

Energy Source	Number of villages	Number of households	Number of households to be electrified	Installed Capacity (KW)	Construction Cost (x 1,000 US$)	
				Total	Total	Estimated cost per household
Grid Extension	753	208,520	208,250	42,000	62,600	300
Solar BCS	1,720	237,570	190,000	8,487	52,891	280
Individual SHS (planned by the WB)			12,000		4,800	400
Mini grid						
Micro hydro Hybrid (micro hydro and biomass gasification)	137	18,541	14,833	2,078	14,069	950
Biomass gasification	3,071	501,636	804,844	104,644	342,537	430
Grid extension or Biomass gasification	3,257	504,397				
Diesel	392	69,390	291,011	37,831	87,303	300
Grid extension or Diesel	1,875	294,374				
Sub Total	**11,205**	**1,834,428**	**1,521,208**	**194,740**	**564,200**	**370**
Indirect costs (Sub Total x 30%) (including the administrative management, technical and operational supports, and reserves)					169,260	110
Total	**11,205**	**1,834,428**	**1,521,208**	**194,740**	**733,460**	**480**

Source: JICA Study Team

Tables 2.4.5 to 2.4.8 present the calculation sheets for each of the following (These files are available on the server of the JICA Study Team):

- Constants employed;
- Mini-grid by micro hydro;
- Mini-grid by biomass gasification power; and
- Solar BCS including PV systems for public facilities.

The constants given in Table 2.4.5 shall be reviewed and updated as needed.

Table 2.4.5 Constants for Planning of Electrification Plan

No.	Name	Value	Definition
1	Hd	0.1	Average household power demand, kW
2	Allow	1.3	Ratio of gen. capacity to load
3	MonkWh	10	Monthly household consumption, kWh
4	Tope	3.03	Daily operation hours
5	FCR	1.50	Fuel consumption rate of BG power plant,
6	Costfuel	20.00	Price of fuel trees, $/ton
7	OMgen	1.0%	Ratio of O&M costs of gene. Equipment
8	Costopef	1,200	Operator costs, fixed
9	Costopev	60	Operator costs, in proportion to generating capacity, 60 (Pi - 19) in $
10	Rhe	80.0%	Ratio of households to be electrified by mini-
11	Rsp	90.0%	Ratio of households to be electrified by battery
12	LVmh	34	m per houshold, average length of LV lines of
13	LVbg	15	m per houshold, average length of LV lines of
14	MVbg	2	m per houshold, average length of MV lines of BG system
15	LVdg	15	m per houshold, average length of LV lines of
16	MVdg	2	m per houshold, average length of MV lines of BG system
15	Cost_GEmh	4.00	Cost of generating equipment, 1000$/kW
16	Cost_GEbg	1.50	Cost of generating equipment, 1000$/kW
17	Cost_Gedg	0.50	Cost of generating equipment, 1000$/kW
18	Cost_MV	10	Cost of MV lines (22 kV), 1000$/km
19	Cost_LV	14	Cost of LV lines (400/230 V), 1000$/km
20	Php	240	Demand of health post, Wp
21	Pns	480	Demand of night school, Wp
22	Pch	200	Demand of community hall, Wp
23	Costhp	2.0	Cost of health post, $1000
24	Costns	5.0	Cost of night school, $1000
25	Costch	2.0	Cost of community hall, $1000
26	i	0.04	Discount rate
27	n	25	Assessment period
28		2.6658	Parameter
29	CRF	0.0640	Capital recovery factor

Source: JICA Study Team

Table 2.4.6 Form for Planning and Ranking of Mini-Grids by Micro Hydro

Data to be Prepared by MH Team

No.	MHP Reference No.	ID No. of RE Scheme	Name of RE Scheme	Single or Multi-Village Scheme	Sub-scheme No.	Province	District	Commune Name	Village Name	ID No. by Seila	Potential Dry Season Power P_d	Length of MV Trans. Lines (km)	Const. Cost incl. Conti @ 30% ($1,000)	1 Maturity (A/R/S/N)	2 Dif-fusion level of battery (%)	3 Distance to provincial capital (km)	4 Province Code	5-1 Q & H measured? (Y/N)	5-2 Length of new access road (km)	5-3 Cost per HH ($/hh)	5-4 Free from land-mine? (Y/N)	7 Any daytime demand? (Y/N)	8 Dif-fusion level of TV (%)	9 Any comm. activities or popular industry?	10 Nos. of house-holds	Remarks on Daytime demand incl. BCS, Community activities, ATP
1	8-12	MH1105-01	**O Moleng**	11	1	Mondul Kiri	Saen Monourom	Monourom	Daeum Sral	11050101	82	5.0	189.8	S	2.44	5	11	Y	0.2	580	Y	N	36.89	N	1,434	
2	8-13	MH1105-02	**O Romis**		2	Mondul Kiri	Saen Monourom	Monourom	Chrey Saen	11050102	19	1.5	74.1	S		7	11	Y	1.4		Y	N		N		
3	8-14	MH1105-03	**Prek Dak Deurr**		3	Mondul Kiri	Saen Monourom	Sokh Dom	Mean Leaph	11050201	33	9.0	102.7	S		9	11	Y	0.5		Y	N		N		
4	8-15	MH1105-04	**Prek Dak Deurr D/S**	11	4	Mondul Kiri	Saen Monourom	Sokh Dom	Daoh Kramom	11050202	206	4.5	481.0	S	2.44	13	11	Y	6.0	669	Y	N	36.89	N	1,434	
					5	Mondul Kiri	Saen Monourom	Sokh Dom	Svay Chek	11050203																
					6	Mondul Kiri	Saen Monourom	Sokh Dom	Lao ka	11050204																
					7	Mondul Kiri	Saen Monourom	Spean Mean Chey	Ou Spean	11050301																
					8	Mondul Kiri	Saen Monourom	Spean Mean Chey	Chambak	11050302																
					9	Mondul Kiri	Saen Monourom	Spean Mean Chey	Kandal	11050303																
					10	Mondul Kiri	Saen Monourom	Spean Mean Chey	Chamkar Tae	11050304																
					11	Mondul Kiri	Saen Monourom	Romonea	Pu Tang	11050402																
5	10-2	MH1605-01	**O Katieng**	4	1	Ratanak Kiri	Lumphat	La Bang Muoy	Kam Phlenh	16050301	40	6.5	76.7	S	0.00	7.5	16	Y	0.5	808	Y	N	5.76	N	295	
					2	Ratanak Kiri	Lumphat	La Bang Muoy	Ka Tieng	16050303																
					3	Ratanak Kiri	Lumphat	La Bang Muoy	Ka Lang	16050304																
					4	Ratanak Kiri	Lumphat	La Bang Pir	Ka Tieng	16050401																
6	1-2	HB0209-01	**Sangke D/S**	45	1	Battambang	Rotonak Mondol	Phlov Meas	Phlov Meas	2070301	59	115.0	232.7	S	0.44	50	2	Y	1.0	697	N	N	22.09	N	6,786	Hybrid with Biomass Power
	1-3	HB0209-02	**Sangke U/S**		2	Battambang	Rotonak Mondol	Phlov Meas	Tuek Sab	2070303	85		416.0	S		76	2		3.0		Y					
					3	Battambang	Rotonak Mondol	Phlov Meas	Ou Treng	2070305																
					4	Battambang	Rotonak Mondol	Phlov Meas	Ou Lmun	2070307																
					5	Battambang	Rotonak Mondol	Traeng	Kilou	2070401																
					6	Battambang	Rotonak Mondol	Traeng	Phcheav	2070402																
					7	Battambang	Rotonak Mondol	Traeng	Chea Montrei	2070403																
					8	Battambang	Rotonak Mondol	Traeng	Chi Sang	2070404																
					9	Battambang	Rotonak Mondol	Traeng	Svay Sa	2070406																
					10	Battambang	Rotonak Mondol	Traeng	Ta Krok	2070407																
					11	Battambang	Samlout	Ou Samrel	Ou Rumchek Kraom	2090201																
					12	Battambang	Samlout	Ou Samrel	Ou Rumchek Leu	2090202																
					13	Battambang	Samlout	Ou Samrel	Chamlang Romean	2090203																
					14	Battambang	Samlout	Ou Samrel	Ou Samrael Kraom	2090206																
					15	Battambang	Samlout	Ou Samrel	Ou Samrael Leu	2090209																
					16	Battambang	Rotonak Mondol	Phlov Meas	Sek Sak	2070302																
					17	Battambang	Rotonak Mondol	Phlov Meas	Chi Pan	2070304																
					18	Battambang	Rotonak Mondol	Phlov Meas	Ou Da	2070306																
					19	Krong Pailin	Pailin	Ou Tavau	Kra Chab	24010206																
					20	Battambang	Samlout	Ou Samrel	Chamlang Romean	2090204																
					21	Battambang	Samlout	Mean Cheay	Sre Sdao	2090401																
					22	Battambang	Samlout	Mean Cheay	Kampong Touk	2090402																
					23	Battambang	Samlout	Mean Cheay	Sre Chi Pao	2090403																
					24	Battambang	Samlout	Mean Cheay	Kam Chat	2090404																
					25	Battambang	Samlout	Mean Cheay	Ambib	2090405																
					26	Battambang	Samlout	Mean Cheay	Ta Non	2090406																
					27	Battambang	Samlout	Samlout	Chhar RoKar	2090501																
					28	Battambang	Samlout	Samlout	Kantuot	2090502																
					29	Battambang	Samlout	Samlout	Ou Chrab	2090503																
					30	Battambang	Samlout	Samlout	Samlout	2090504																
					31	Battambang	Samlout	Samlout	Srae Andoung Mea	2090505																
					32	Battambang	Samlout	Samlout	Buang Run	2090506																
					33	Battambang	Samlout	Sung	Chamkar Chek	2090601																
					34	Battambang	Samlout	Sung	Kandal	2090602																
					35	Battambang	Samlout	Sung	Kanh Chaang	2090603																
					36	Battambang	Samlout	Sung	Sre Reach	2090606																
					37	Battambang	Samlout	Sung	Shoung Muoy	2090607																
					38	Battambang	Samlout	Sung	Shuong Pir	2090608																
					39	Battambang	Samlout	Ta Sanh	Anlong Pouk	2090701																
					40	Battambang	Samlout	Ta Sanh	Doun Troek	2090702																
					41	Battambang	Samlout	Ta Sanh	Ou Sngout	2090703																
					42	Battambang	Samlout	Ta Sanh	Ou Tontim	2090704																
					43	Battambang	Samlout	Ta Sanh	Prey Rumchek	2090705																
					44	Battambang	Samlout	Ta Sanh	Ta Sanh Khang Ch	2090706																
					45	Battambang	Samlout	Ta Sanh	Ta Sanh Khang Tb	2090707																
7	1-2	HB0209-03	**Sangke D/S Alternative**	8	1	Battambang	Rotonak Mondol	Phlov Meas	Phlov Meas	2070301	59	13.0	232.7	S	1.81	50	2	Y	1.0	665.0	N	N	20.39	N	1,324	
					2	Battambang	Rotonak Mondol	Phlov Meas	Sek Sak	2070302																
					3	Battambang	Rotonak Mondol	Phlov Meas	Tuek Sab	2070303																
					4	Battambang	Rotonak Mondol	Phlov Meas	Ou Treng	2070305																
					5	Battambang	Rotonak Mondol	Phlov Meas	Chi Pan	2070304																
					6	Battambang	Rotonak Mondol	Traeng	Phcheav	2070402																
					7	Battambang	Rotonak Mondol	Traeng	Kilou	2070401																
					8	Battambang	Rotonak Mondol	Traeng	Chea Montrei	2070403																
8	10-10	MH1605-02	**Bay Srok**	3	1	Ratanak Kiri	Lumphat	Ka Laeng	Bay Srok	16050204	65	3.0	139.1	S	34.11	35	16	Y	0.0	587	Y	N	7.86	N	560	Issue of Target Village; Road more than 10 km to be upgraded
					2	Ratanak Kiri	Lumphat	Ka Laeng	New Ka Laeng	16050205																
					3	Ratanak Kiri	Lumphat	Ka Laeng	New Sayos	16050206																
9	8-17	MH1104-01	**Bu Sra (O Phlai or Bu Sra W.F)**	10	1	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Muoy	11040401	91	25.0	461.5	R	0.22	46	11	Y	11.0	1,201	Y	N	1.22	N	899	To be planned by O Phlai or Bu Sra W.F; Some other villages near O Phlai; New access road - O Phlai 11 km - Bu Sra 0.5 km
					2	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Pir	11040402																
					3	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Bei	11040403																
					4	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Buon	11040404																
					5	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Pram	11040405																
					6	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Pramm	11040406																
					7	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Prampi	11040407																
					8	Mondul Kiri	Pech Chenda	Srae Ampum	Phum Lekh Muoy	11040301																
					9	Mondul Kiri	Pech Chenda	Srae Ampum	Phum Lekh Pir	11040302																
					10	Mondul Kiri	Pech Chenda	Srae Ampum	Phum Lekh Bei	11040303																
10	6-19	MH0908-01	**O Sla D/S**	4	1	Koh Kong	Kampong Seila	Kampong Seila	Cham Srei	9080201	283	15.0	543.4	N	0.40	175	9	N	15.0	904	Y	N	13.13	N	1,249	
					2	Koh Kong	Kampong Seila	Kampong Seila	Krang at	9080202																
					3	Koh Kong	Kampong Seila	Kampong Seila	Thmei	9080203																
					4	Koh Kong	Kampong Seila	Kampong Seila	Veal	9080204																
11	9-1	MH1506-02	**Xtung Tun Po**	3	1	Pursat	Veal Veaeng	Pramaoy	Stueng Thmei	15060403	55	11.0	120.9	N	0.00	120	15	N	1.0	849	N	N	14.63	N	451	
					2	Pursat	Veal Veaeng	Pramaoy	Tumpor	15060405																
					3	Pursat	Veal Veaeng	Pramaoy	Pramaoy	15060404																
12	5-9	HB0704-01	**Srae Cheng**	1	1	Kampot	Chum Kiri	Srae Chaeng	Pong Tuek	7040404	6	8.0	22.1	S	0.00	65	7	Y	10.0	818	N	N	26.76	N	284	Hybrid with Biomass Power
13	6-12	MH0907-01	**Tatai D/S**	2	1	Koh Kong	Thma Bang	Ruessei Chrum	Trapeang Chheu Tr	9070403	62	10.0	122.2	S	0.00	60	9	Y	1.5	2,006	Y	N	13.55	N	155	
					2	Koh Kong	Thma Bang	Ruessei Chrum	Kokir Chrum	9070404																
14	1-1	MH0209-01	**Tributary Stung Cra Nhung**	14	1	Battambang	Samlout	Ta Taok	OU Nonoung	2090101	330	33.0	603	N	0.00	90	2	N	12.0	1,592	N	N	12.20	N	844	
					2	Battambang	Samlout	Ta Taok	Ou Traeng	2090103																
					3	Battambang	Samlout	Ta Taok	Peam Ta	2090104																
					4	Battambang	Samlout	Ta Taok	Peam	2090105																
					5	Battambang	Samlout	Ta Taok	Ou Ta Teak	2090106																
					6	Battambang	Samlout	Ta Taok	Ta Tok	2090107																
					7	Battambang	Samlout	Ta Taok	Veal Roluem	2090108																
					8	Battambang	Samlout	Ta Taok	Phnum Rai	2090109																
					9	Battambang	Samlout	Kampong Lpou	Svay Chrum	2090301																
					10	Battambang	Samlout	Kampong Lpou	Ou Daem Chek	2090302																
					11	Battambang	Samlout	Kampong Lpou	Ou Choam Kandal	2090304																
					12	Battambang	Samlout	Kampong Lpou	Ou Choam Kraom	2090305																
					13	Battambang	Samlout	Kampong Lpou	Ou Choam Leu	2090306																
					14	Battambang	Samlout	Kampong Lpou	Kandal	2090307																
15	9-6	MH1504-01	**O Leach Meas**	2	1	Pursat	Phnum Kravanh	Samraong	Roveang	15040710	35	13.0	74.1	N	0.00	60	15	N	3.0	1,772	N	N	14.02	N	164	MV Line Long
					2	Pursat	Phnum Kravanh	Samraong	Ongkrong	15040711																

Data to be Referred to Seila Database and Calculated

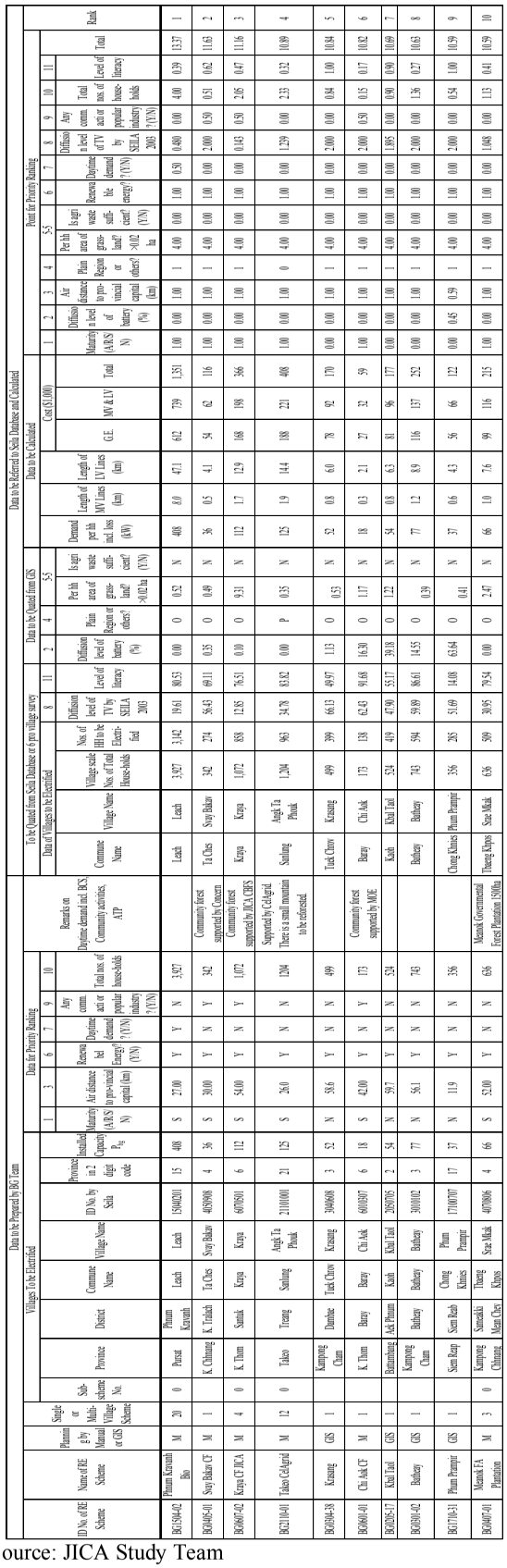
No.	Commune Name	Village Name	Nos. of Total Households	11. Level of literacy	4. Plain Region or others?	Nos. of HH to be Electrified	Total Demand incl. loss (kW)	Installed Capacity of MHP (kW)	Backup Capacity P_{sub} (kW)	Length of LV Lines (km)	Cost G.E. ($1,000)	Cost Back up	Cost MV & LV	Cost Total
1	Monourom	Daeum Sral	1,434	74	O	1147	149	82	15	17.2	190	8	291	665
2								19			74			
3								33			103			
4	Sokh Dom	Daoh Kramom	1,434	74	O	1147	149	149	0	17.2	481	0	286	767
5	La Bang Muoy	Kam Phlenh	295	16	O	236	31	31	0	3.5	77	0	114	191
6	Phlov Meas	Phlov Meas	6,786	78	O	5429	706	59 / 85	562	81.4	649	843	2,290	3,781
7	Phlov Meas	Phlov Meas	1,324	78	O	1059	138	59	79	15.9	233	119	353	704
8	Ka Laeng	Bay Srok	560	0	O	448	58	58	0	6.7	139	0	124	263
9	Bu Sra	Phum Lekh Muo	899	32	O	719	93	91	2	10.8	462	1	401	864
10	Kampong Seila	Cham Srei	1,249	57	O	999	130	130	0	15.0	543	0	360	903
11	Pramaoy	Stueng Thmei	451	50	O	361	47	47	0	5.4	121	0	186	307
12	Srae Chaeng	Pong Tuek	284	66	P	227	30	6	24	3.4	22	36	128	186
13	Ruessei Chrum	apeang Chheu T	155	83	O	124	16	16	0	1.9	122	0	127	249
14	Ta Taok	OU Nonoung	844	80	O	675	88	88	0	10.1	603	0	471	1,075
15	Samraong	Roveang	164	25	O	131	17	17	0	2.0	74	0	158	232

Point for Priority Ranking

No.	1 Maturity (A/R/S/N)	2 Dif-fusion level of battery (%)	3 Distance to provincial capital (km)	4 Plain Region or others?	5-1 Q & H measured? (Y/N)	5-2 Length of new access road (km)	5-3 Cost per HH ($/hh)	5-4 Free from land-mine? (Y/N)	6 Renewable energy?	7 Any daytime demand? (Y/N)	8 Dif-fusion level of TV (%)	9 Any comm. acti or popular industry? (Y/N)	10 Nos. of house-holds	11 Level of literacy	Total	Rank and Remarks
1	1.00	0.00	0.25	1.00	1.00	0.96	1.16	0.50	2.00	0.00	1.34	0.00	2.81	0.51	**12.54**	B/D on going by Japanese Grant
4	1.00	0.00	0.65	1.00	1.00	0.00	1.00	0.50	2.00	0.00	1.34	0.00	2.81	0.51	**11.81**	Superior site for succeeding project to the above Japanese Grant Scheme
5	1.00	0.00	0.38	1.00	1.00	0.90	0.74	0.50	2.00	0.00	0.00	0.00	0.41	1.00	**8.92**	On going by UNIDO
6	1.00	0.00	1.00	1.00	1.00	0.20	0.94	0.25	2.00	0.00	0.60	0.00	4.00	0.44	**12.43**	**1**
7	1.00	0.00	1.00	1.00	1.00	0.80	1.00	0.00	2.00	0.00	0.52	0.00	2.58	0.44	**11.34**	**2**
8	1.00	0.00	1.00	1.00	1.00	1.00	1.15	0.50	2.00	0.00	0.00	0.00	0.97	1.00	**10.62**	**3**
9	2.00	0.00	1.00	1.00	1.00	0.00	0.00	0.50	2.00	0.00	0.00	0.00	1.68	1.00	**10.18**	**4**
10	0.00	0.00	1.00	1.00	0.00	0.00	0.56	0.50	2.00	0.00	0.16	0.00	2.42	0.87	**8.50**	**5**
11	0.00	0.00	1.00	1.00	0.00	0.80	0.66	0.00	2.00	0.00	0.23	0.00	0.74	1.00	**7.43**	**6**
12	0.50	0.00	1.00	0.00	1.00	0.00	0.72	0.00	2.00	0.00	0.84	0.00	0.39	0.68	**7.12**	**7**
13	1.00	0.00	1.00	1.00	1.00	0.70	-1.51	0.50	2.00	0.00	0.18	0.00	0.12	0.35	**6.33**	**8**
14	0.00	0.00	1.00	1.00	0.00	0.00	-0.74	0.00	2.00	0.00	0.11	0.00	1.57	0.41	**5.35**	**9**
15	0.00	0.00	1.00	1.00	0.00	0.40	-1.07	0.00	2.00	0.00	0.20	0.00	0.13	1.00	**4.66**	**10**

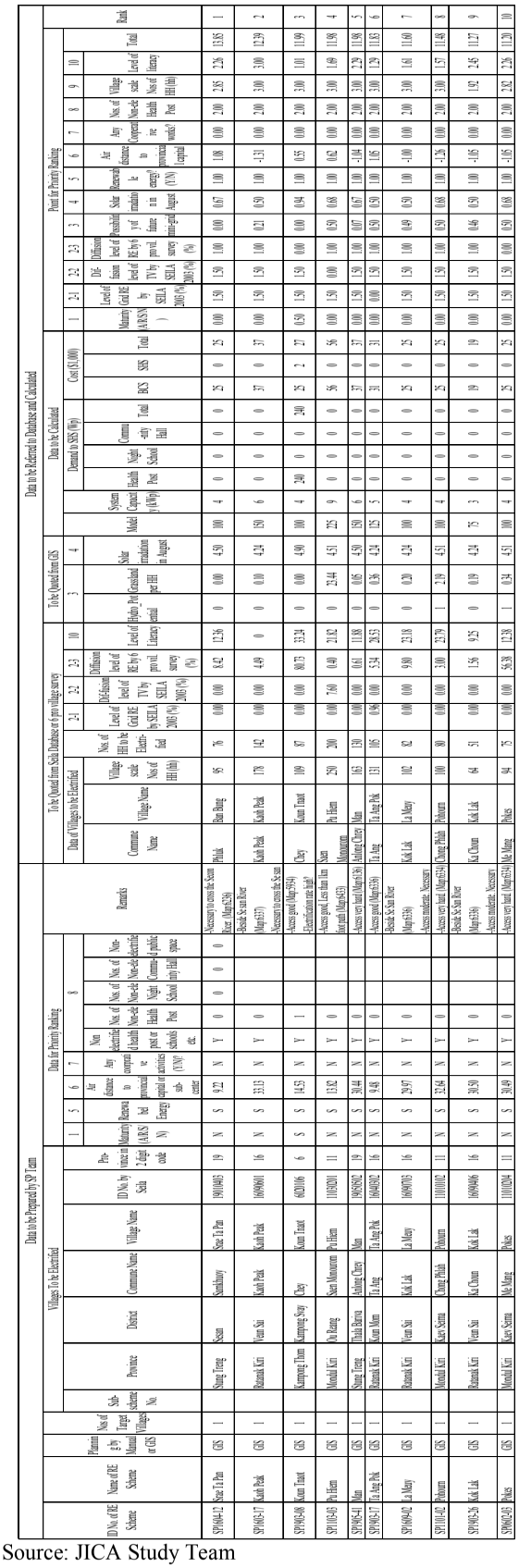
Source: JICA Study Team

Table 2.4.7 Form for Planning and Ranking of Mini-Grids by Biomass Gasification Power



Source: JICA Study Team

Table 2.4.8 Form for Planning and Ranking of Solar BCS and PV Systems for Public Facilities



Source: JICA Study Team

2.5 PRIORITY RANKING FOR IMPLEMENTATION

2.5.1 Ranking Criteria of Priority Schemes

A flowchart for selection of priority development schemes is presented in Figure 2.5.1.

(1) According to the criteria for selection of energy source given in Figure 2.4.3, all the villages in Cambodia shall be classified with GIS database into the following groups:

Table 2.5.1 Grouping of Villages by Source of Energy with GIS Database

Region			Electrification Plan				
			RE Stage	Load		Type	Source of Energy
				Watt	kWh/m		
Whole Country	Inside PAGE	On-Grid	3	<400	50	grid	National grid, Licensed RE, Non-licensed REE
	Outside PAGE	Off-Grid	2	100 (30-200 W depending on income level)	10	Isolated mini-grids	Micro hydro, 24 hour
							Biomass gasification power, hourly supply
							Diesel power, hourly supply
			1	10 (40 W in h.h. using TV)	3	BCS, PV systems for public facilities	existing diesel generator and solar PV systems, use when necessary

Source: JICA Study Team

(2) Electrification plan of each village shall be refreshed by re-inputting the updated data in the following two ways:

1) For the villages that have been surveyed by the MIME team or for which applications have been received from REE or relevant village organization, village data shall be filled in using respective forms presented in Tables 2.4.6 to 2.4.8.

2) For the other villages not surveyed at all, the necessary information shall be extracted from the latest version of Seila database using GIS.

(3) Preliminary cost estimate will be updated automatically together with the electrification planning above. Therefore, the following unit costs data of respective energy sources shall be reviewed and updated as basic data for updating the Master Plan:

1) Solar BCS: standard costs are shown in Table 6.3.1 of Part 2.

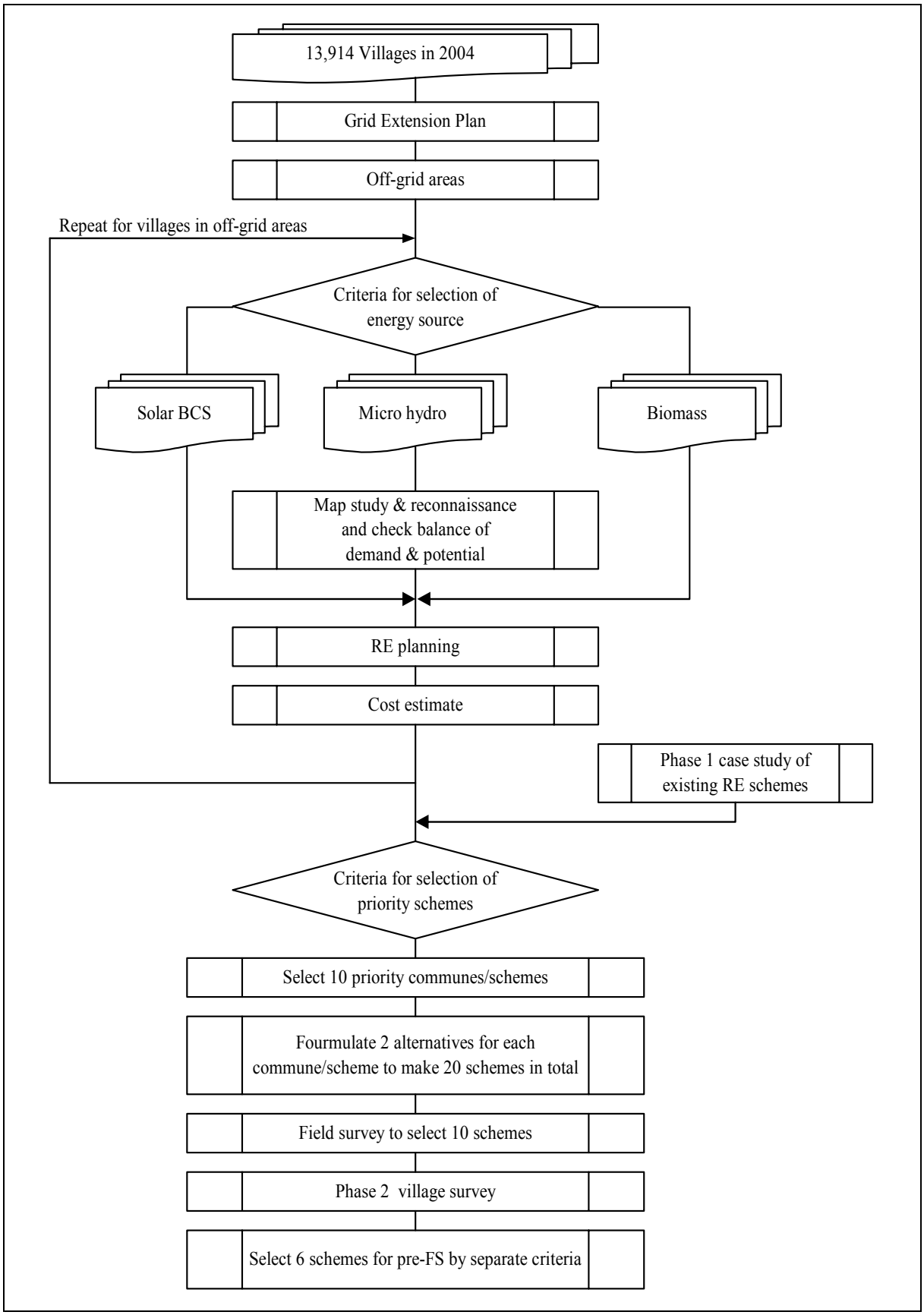
2) PV systems for *social electrification*: standard costs shown in Table 6.4.1 of Part 2.

3) Cost data of micro hydro: refer to Section 5.5 of Part 2 for cost estimate of generating facilities and equipment. The length of MV transmission and LV distribution lines are to be updated, if necessary.

(4) Selection Criteria for Priority Schemes

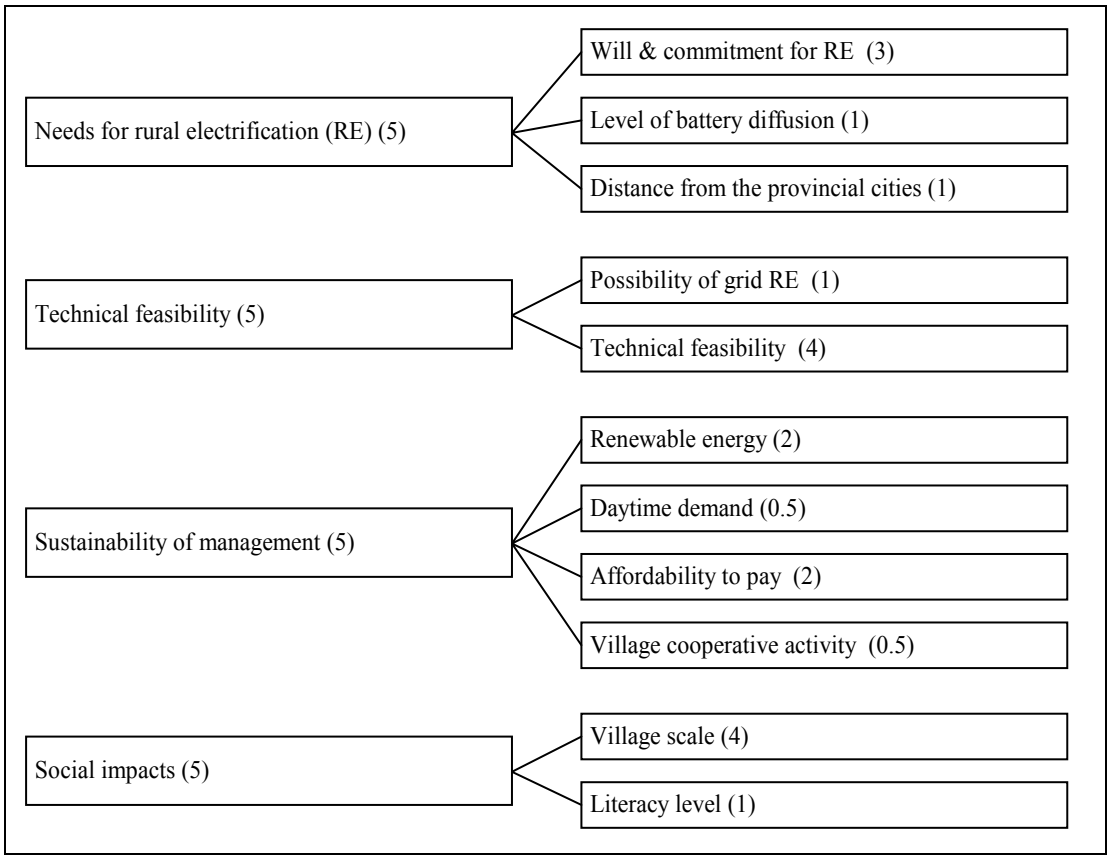
Following the concept of Analytic Hierarchy Process (AHP), the following hierarchal structure is adopted to formulate selection criteria of priority development plans, aiming at publicity and accountability. Hierarchal structures for mini-grid selection criteria and their weights are shown in Figure 2.5.2.

Four groups of the first hierarchy are established and the same weight of five points each is allocated to each group. These parameters and weights need review and updating. Figure 2.5.3 shows parameters and weights for selection of RE schemes with solar BCS.



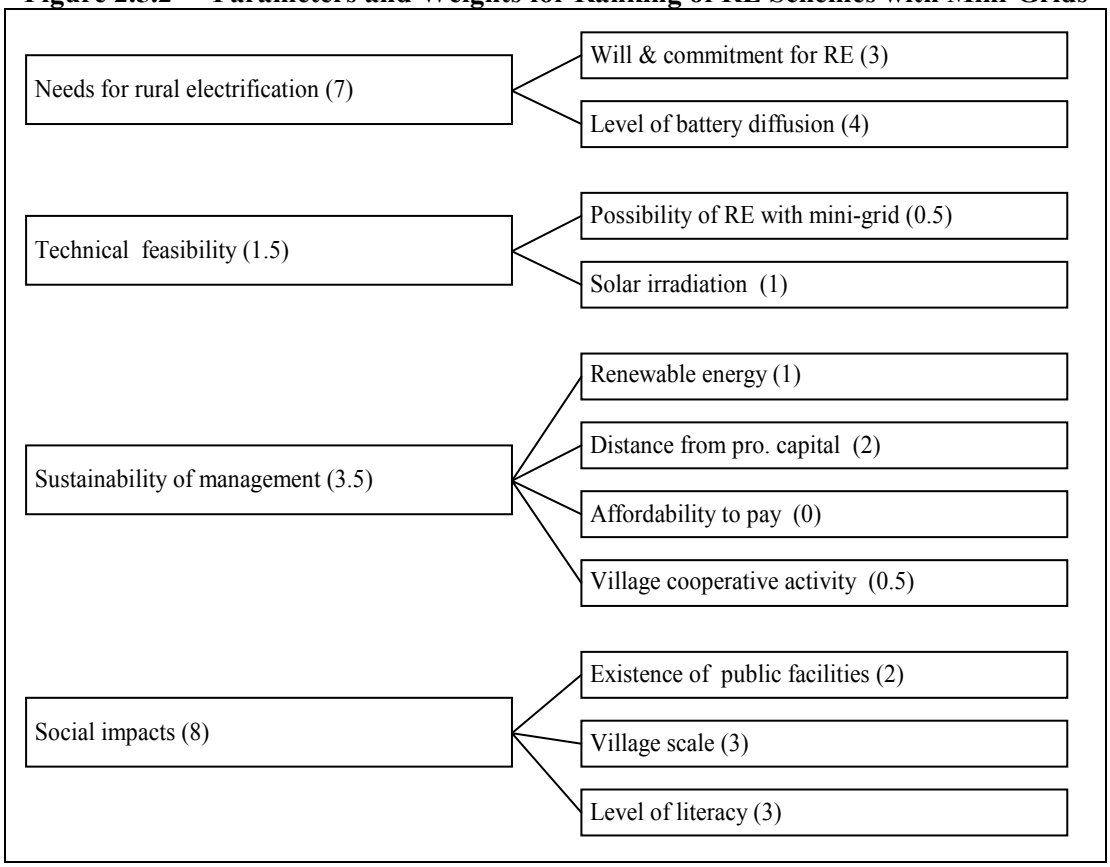
Source: JICA Study Team

Figure 2.5.1 Flowchart for Selection of Priority Schemes



Source: JICA Study Team

Figure 2.5.2 Parameters and Weights for Ranking of RE Schemes with Mini-Grids



Source: JICA Study Team

Figure 2.5.3 Parameters and Weights for Ranking of RE Schemes with Solar BCS

(5) A case study was made in June 2005 on two existing electrification schemes. Its findings are summarized below:

The case studies conducted in June 2005 on two existing electrification schemes demonstrates viable criteria for community based electrification. These are summarized as below:

1) Willingness and ability to pay among potential beneficiaries
2) Willingness and ability to engage in potential supplemental income-generating activities
3) Willingness to contribute community counterpart (resources or labor) (Entrepreneurs willing to invest in the electrification project)
4) Viable community based organization
5) Viable and technically sound external NGO/ organization for social preparation, project establishment and monitoring work
6) Availability of local credit organizations and facilities
7) Availability of local resources Natural – land, forest, water Human – population and growth, availability of local skills/ potential skills

Items 1) - 3) of the suggested criteria are "must" requirements in the selection process. These are demonstrations of the villages' commitment and support to the project and must first be elicited prior to start of the project.

Items 4) and 5) are preferred existing conditions at candidate villages. If such are absent, the project design must compensate for this lack i.e. incorporate programs on organization establishment, capacity building and sustained institutional support utilizing existing NGO.

Criteria number 6) is also optional, but highly preferred. In case local credit facilities do not exist in candidate villages, the project design must incorporate the necessary measures for financing the connecting fees for individual beneficiaries and financing the necessary equipments for the project. This can be done by either building a credit system within the project itself or partnering with external credit organizations such that credit services/ facilities will be available to the target village.

Criteria 7) will be identified under project implementation and developed towards complementation with the electrification project's objectives.

Ranking of each RE scheme will be made by point system (full score at 20). The assessment is based on the ATP as shown in Tables 2.5.2 and 2.5.3.

The point system for solar lighting is shown in Table 2.5.2 while that for mini-grids of micro hydro or biomass gasification power in Table 2.5.3.

Table 2.5.2 Ranking of Solar BCS and PV Systems for Public Facilities

No.	Parameters		Point	Remarks
Needs to RE, 7 points				
1	Maturity (Villagers' motivation will be given the top priority within the RE fund available.)	A	**3**	Applied
		R	**2**	Requested to PDC
		S	**0.5**	Points in inverse proportion to distance up to nearest BCS
		N	0	No or not known
2	Diffusion level of mini-grid or gen-set by Seila 2003	= 0%	**1.5**	Solar BCS only to no grid no gen-set villages
		> 0%	0	
	Diffusion level of Tv by Seila 2003	= 0%	**1.5**	
		> 0%	0	
	Diffusion level of RE by 6 pro vil. survey	<= 10%	**1**	
		> 10%	0	
Technical feasibility, 1.5 points				
3	Possibility of future mini-grid (either as micro hydro or as biomass)	**Micro hydro plan?**	**0.5**	potential of micro hydro
		Land for biomass?		potential of mini-grid by biomass
		>= 0.20 ha	**0.5**	
		= 0.02 ha	0	
		P = 2.7778 A - 0.0556		
4	Solar irradiation in August	>= 5.0 kWh/m2/day	**1**	Data by province, intraporated from NASA data
		= 3.5 kWh/m2/day	0	
		P = 0.667 Si - 2.333		
Sutainability of operation and management, 3.5 points				
5	Renewable energy?	Solar	**1**	no fuel, 24 hour
		Diesel	**0**	high cost of imported fuel
6	Air distance L (km) to provincial capital or selected towns	= 0 km	**2**	priority to zones surroudning provincial capital or towns minus point for remote
		= 20 km	0	
		>= 40 km	-2	
		P = 2 - 2 L / 20		
7	Is there any activity like credit union in village?	Yes	**0.5**	Contibute to sustaining O&M by CBO in particular
		No or not known	0	
Social effects of RE scheme, 8 points				
8	Non-electrified health center/post, night school or community hall exists	Yes	**2**	*social electrification* of public faicilities given priority
		No or not known	0	
9	Village scale, V_s	> 100 households	**3**	Points in proportion to village scale < 100 hh
		none	0	
		P = 0.03 V_s		
10	Level of literacy	= 0%	**3**	Contribution to poverty reduction Minus point for over 50%
		= 50%	0	
		= 100%	-3	
		P = 3 - 0.06 Li		
		Highest score	20	

Source: JICA Study Team

Table 2.5.3 Ranking of Mini-grids

No.	Parameters/Questions	Answer/Criteria	Point	Remarks
Needs to RE, 5 points				
1	Maturity (Villagers' motivation will be given the top priority within the RE fund available.)	A	**3**	Applied to REF
		R	**2**	Requested to PDC
		S	**1**	Surveyed to confirm demand for RE and potential
		N	0	No or not known
2	Difusion level of battery electrification, L_b	> 80%	**1**	Points for diffusion level > 50%
		@ 50%	0	
		P = 0.0333 Lb - 1.665		Minus points for <50%
3	Air distance L (km) to provincial capital	> 20 km	**1**	a parameter on the time till grid connection
		P = 0.05 L		
Technical feasibility, 5 points				
4	Plain Region or others	Other Region	**1**	In Plain Region, grid extension to be examined first
		Plain Region	0	
Mini-grids by micro hydro				
5-1	H & Q in dry season measured on site?	Yes	**1**	two basic resources of hydropower
		No or not known	0	
5-2	Length of new access road L	Not required at all	**1**	Parameter on costs and time for implementation
		>= 5 km	0	
		P = 1- 0.2 L		
5-3	Cost per household?	< $400/hh	**1.5**	Information from site survey and CMAC maps
		=$1,200/hh	**0**	
		P = 2.25 - 1.5 C / 800	0	
5-4	Is it free from landmines?	Yes	**0.5**	Information from site survey and CMAC maps
		No or not known	0	
Mini-grids by biomass gasification power				
5-5	Area of grassland for farming trees? (ha per hh), or Agricutural/forest waste	>= 0.20 ha	**4**	to put points for grassland >= 0.02 ha screened out if < 0.02 ha
		= 0.02 ha	0	
		No or not known	0	
		P = 22.22 Ag - 0.444		
Sutainability of operation and management, 5 points				
6	Renewable energy?	Micro hydro	**2**	no fuel, 24 hour operation
		Biomass gasification	**1**	cheap domestic fuel
		Diesel	**0**	high cost of imported fuel
7	Any daytime demand?	Yes	**0.5**	to lower tariff
		No or not known	0	
8	Diffusion level of TV	> 50%	**2**	a parameter on ATP
		= 10%	**0**	
		P = 0.05 Tv - 0.5		
9	Is there any activity like credit union or industry popular in village?	Yes	**0.5**	cooperative activities could sustain O&M by CBO in particular
		No or not known	0	
Social effects of RE scheme, 5 points				
10	Total nos. of households, N_h representing scheme benefit	> 500 households	**4**	Points for village scale > 100 hh
		@ 100 households	**0**	
		P = 0.01 Nh - 1		Minus points for < 100 hh
11	Level of literacy	<= 50%	**1**	Contribution to poverty reduction
		= 100%	**0**	
		P = 2 - 0.02 Ll		
		Highest score	20.00	

Source: JICA Study Team

2.5.2 Ranking of RE Schemes with Excel

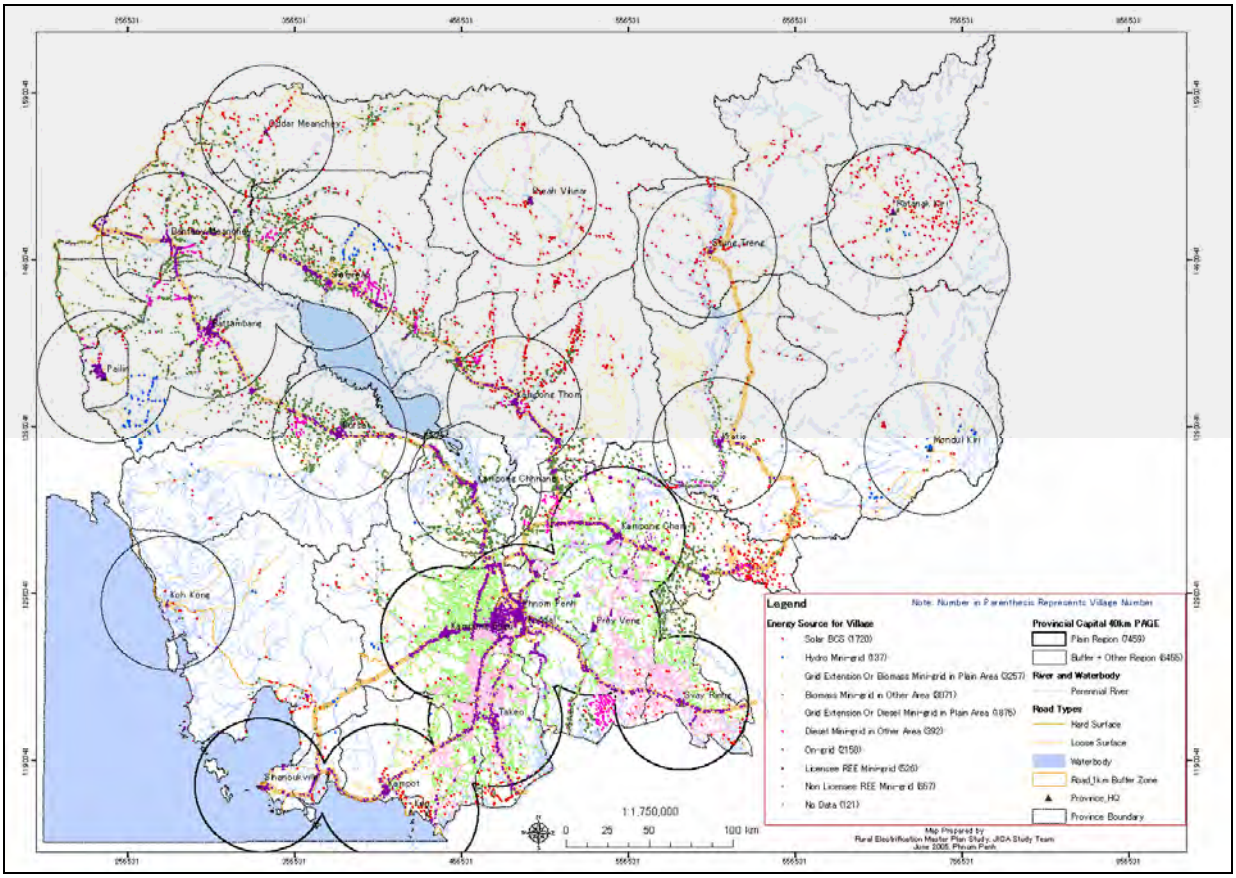
A list of RE schemes selected with mini-grids by micro hydro in the Master Plan 2005 is given in Table 2.4.6, that by biomass gasification power in Table 2.4.7, and that of solar BCS in Table 2.4.8. The location of these villages is shown in Figure 2.5.4.

Ranking of all the RE schemes should be refreshed separately 1) for village group of battery lighting (RE Stage 1), 2) for village group of mini-grid by micro hydro (RE Stage 2), and for village group of mini-grid by biomass gasification power (RE Stage 2). Table 2.5.4 shows a summary of numbers of schemes and villages studied in MP2005 as the baseline in updating the Master Plan.

Table 2.5.4 Number of RE Schemes by Type, MP 2005

No.	Type of Energy	Nos. of schemes			Nos. of Villages Screened with GIS
		Map Study	Schemes Studied with Villages	Inspected Schemes	
1	Hybrid of MH & BG	-	8	5	137 (21 schemes)
2	Micro hydro	145	36	23	
3	Biomass power	13 (Total 48 villages)	13	11	6,328
4	Diesel power	-	-	-	2,267
5	Solar power	21	-	21	1,720
6	Grid extension	-	-	-	753
7	Village w/o data	-	-	-	121
Total		179	57	60	11,326

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.4 Sources of Energy and Type of RE by Village, MP2005

2.6 IMPLEMENTATION PROGRAM

2.6.1 Phased Implementation Schedule

A phased implementation schedule is given in the following table. (see Part-2 "Master Plan" Chapter 2.2.3 Table 2.2.8 Phased Investment Plan by Electrification Type).

Table 2.6.1 Phased Implementation Schedule

Type of Electrification	Households	h.h to be electrified 2005-2020	*Coverage	Phased h.h. to be electrified (h.h.)				Unit cost per h.h.	Total Cost
				2005-2008 15%	2009-2012 25%	2013-2016 30%	2017-2020 30%		
	(h.h.)	(h.h.)	(%)					(US$/h.h	(US$1,000)
Solar BCS	237,570	**60,000**	2.4%	9,000	15,000	18,000	18,000	351	21,045
Indivisual SHS (World Bank Plan)		**12,000**	0.5%	6,000	6,000	0	0	460	5,520
Grid Extension	208,520	**600,000**	24.0%	90,000	150,000	180,000	180,000	467	280,140
Grid extension or Biomass Power	504,397								
Power	294,374								
Micro Hydro/Hybrid of Micro Hydro & Biomass	18,541	**9,000**	0.4%	1,350	2,250	2,700	2,700	1,229	11,064
Biomass Power	501,636	**168,000**	6.7%	25,200	42,000	50,400	50,400	592	99,498
Diesel Power	69,390	**23,000**	0.9%	3,450	5,750	6,900	6,900	424	9,760
Sub total (W/O Solar)	1,596,858	**800,000**	32.0%	120,000	200,000	240,000	240,000		400,462
Total (W/Solar)	1,834,428	**872,000**	34.9%	135,000	221,000	258,000	258,000		427,027

* Percent share of 2.5 million h.h. (national total HHs)

(Source: JICA Study Team)

2.6.2 Funding Schedule

Funding schedule is drawn in the following steps:

Step1 : Make a phased investment plan according to the implementation schedule (Table 2.6.2)

Step2 : Make a phased investment plan by fund sources (Table 2.6.3)

Step3 : Locate financing sources (Table 2.6.4)

Step1 : Phased Investment Plan by Electrification Type

An investment plan by phases is given the following table. (see Part-2 "Master Plan" Chapter 2.2.2 Table 2.2.8 Phased Investment Plan by Electrification Type).

Table 2.6.2 Phased Investment Plan by Electrification Type

Type of Electrification	h.h to be electrified 2005-2020	Unit cost per h.h.	Total Cost	Phased investment ($1,000)			
				2005-2008	2009-2012	2013-2016	2017-2020
	(h.h.)	(US$/h.h	(US$1,000)	15%	25%	30%	30%
Solar BCS	**60,000**	351	21,045	3,157	5,261	6,314	6,314
Indivisual SHS (World Bank Plan)	**12,000**	460	5,520	2,760	2,760	0	0
Grid Extension	**600,000**	467	280,140	42,021	70,035	84,042	84,042
Grid extension or Biomass Power							
Power							
Micro Hydro/Hybrid of Micro Hydro & Biomass	**9,000**	1,229	11,064	1,660	2,766	3,319	3,319
Biomass Power	**168,000**	592	99,498	14,925	24,875	29,849	29,849
Diesel Power	**23,000**	424	9,760	1,464	2,440	2,928	2,928
Sub total (W/O Solar)	**800,000**		400,462	60,069	100,116	120,139	120,139
Total (W/Solar)	**872,000**		427,027	65,986	108,137	126,452	126,452

* Percent share of 2.5 million h.h. (national total HHs)

(Source: JICA Study Team)

Step 2 : Phased Investment Plan by Fund Sources

An investment plan by phases and fund sources is given the following table. (see Part-2 "Master Plan" Chapter 2.2.2 Table 2.2.10 Phased Investment Plan by fund sources (Minimizing Subsidy Case)).

Table 2.6.3 Phased Investment Plan by Fund Sources

Type of Electrification	Ownership (%)		Phased Investment Costs (US$1,000)												Investment Cost(US$1,000)		
			2005-2008			2009-2012			2013-2016			2017-2020			2005-2020 Total		
			Subsidy	Equity	Loan	Subsidy	Equity	Loan	Subsidy	Equity	Loan	Subsidy	Equity	Loan	Subsidy	Equity	Loan
Solar BCS	REE	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CEC	100%	2,999	158	0	4,998	263	0	5,998	316	0	5,998	316	0	19,993	1,052	0
Indivisual SHS (World Bank Plan)	Personal	100%	690	690	1,380	690	690	1,380	0	0	0	0	0	0	1,380	1,380	2,760
Grid Extension	REE	100%	10,505	6,303	25,213	14,007	10,505	45,523	8,404	16,808	58,829	0	21,011	63,032	32,916	54,627	192,596
Grid extension or Biomass Power																	
Grid extension or Diesel Power																	
Micro Hydro & Biomass	REE	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CEC	100%	830	166	664	1,383	277	1,106	1,660	332	1,328	1,660	332	1,328	5,532	1,106	4,426
Biomass Power	REE	60%	2,239	1,343	5,373	2,985	2,239	9,701	1,791	3,582	12,537	0	4,477	13,432	7,015	11,641	41,043
	CEC	40%	1,492	895	3,582	1,990	1,492	6,467	1,791	1,791	8,358	1,194	1,791	8,955	6,467	5,970	27,362
Diesel Power	REE	70%	256	256	512	342	427	939	205	410	1,435	0	512	1,537	803	1,606	4,424
	CEC	30%	110	110	220	146	183	403	132	220	527	88	220	571	476	732	1,720
Total			19,121	9,922	36,943	26,541	16,076	65,520	19,980	23,458	83,013	8,939	28,658	88,854	74,582	78,115	274,331
														Percent Share	17%	18%	64%

(Source: JICA Study Team)

Step 3 : Locate funding sources

The RGC must locate sources to fund the above plan. The indicative funding sources are presented in the following table (Indicative funding sources: see Part-2 "Master Plan" Chapter 2.2.2 Table 2.2.13 Possible Funding Source).

Table 2.6.4 Funding Schedule and Indicative Funding Sources

			Indicative Funding source	Proceeding of MIME/RGC	Remark
REE/ CEC	Equity	15 %	■ Private Fund (REE own fund)		● REE
			■ Partial investment from municipality, community and users		● Municipality/Community
			■ Foreign Direct investment by CDM scheme	● Promote and Capacity Building of CDM in Cambodia	● 2nd step (some biomass projects have possibility)
	Subsidy	25 %	■ REF	● Secure and proceeding the budget	● 1st step
			■ Donation	● Request for other donations	● 2nd step
			■ Cross subsidy system from urban electrified areas	● Examination and enforcement of law revision	● 2nd step
			■ Tax incentive for imported power equipments	● Examination and enforcement of tax reform	● 1st step
	Loan	60 %	■ ODA loan (through RDB etc.)	● Request for ODA loan ● Capacity building of necessary financial system ● Promote necessary guarantee system	● 1st step
			■ Suppliers' credit	● Promote suppliers' credit system ● Promote capable supplies	● 2nd step
			■ Commercial Banks	● Strengthen the banking system	● 2nd step

(Source JICA Study Team)