

**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 1: SUMMARY**

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.

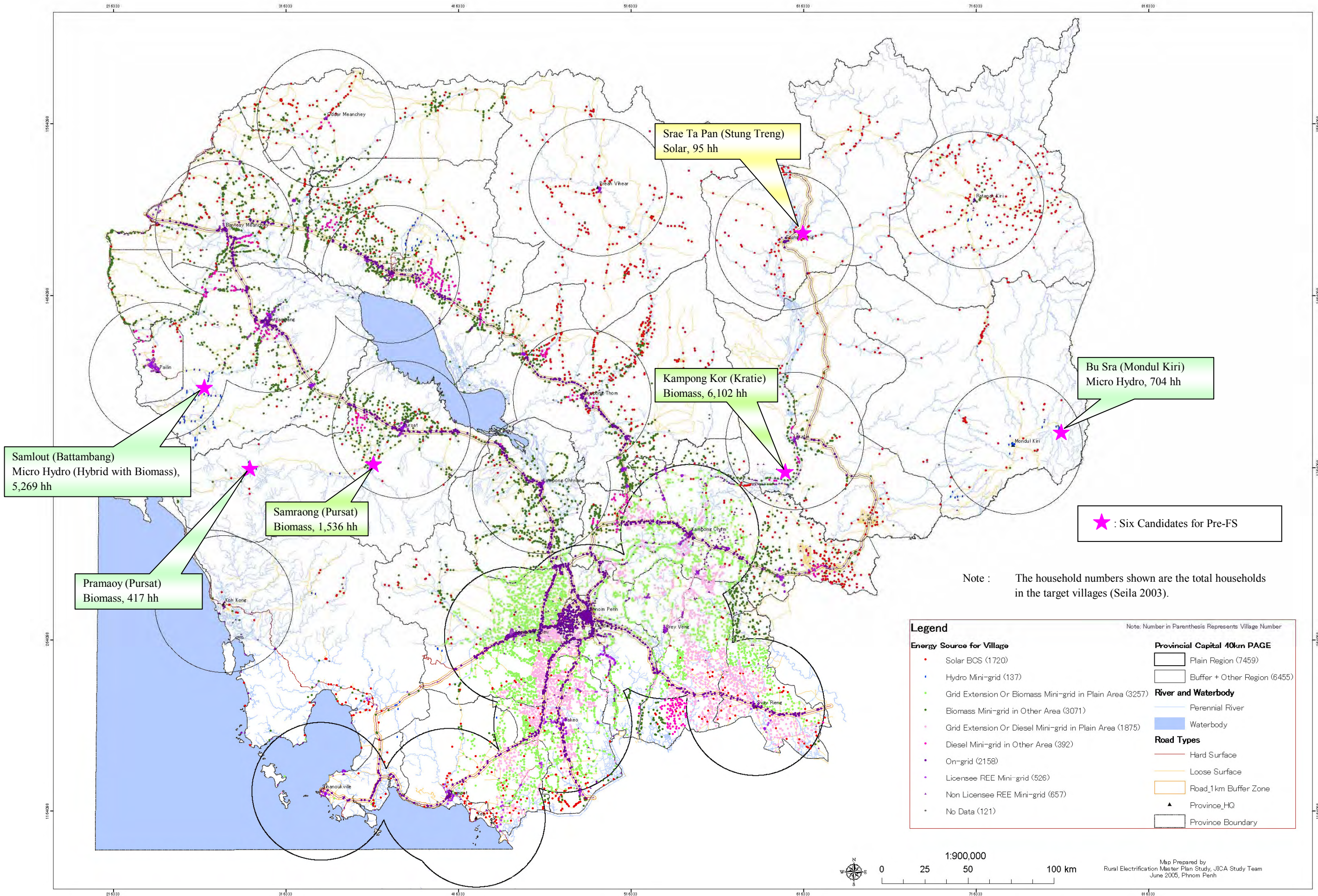
In order to promote awareness and understanding of the private/community driven electrification projects in the off-grid areas, we have - in addition to the Final Report - prepared a visual guide to serve as an illustrated version of the electrification manual. The Visual Guide is in Khmer and English.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



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

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

Final Report

VOLUME 1: SUMMARY

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

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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

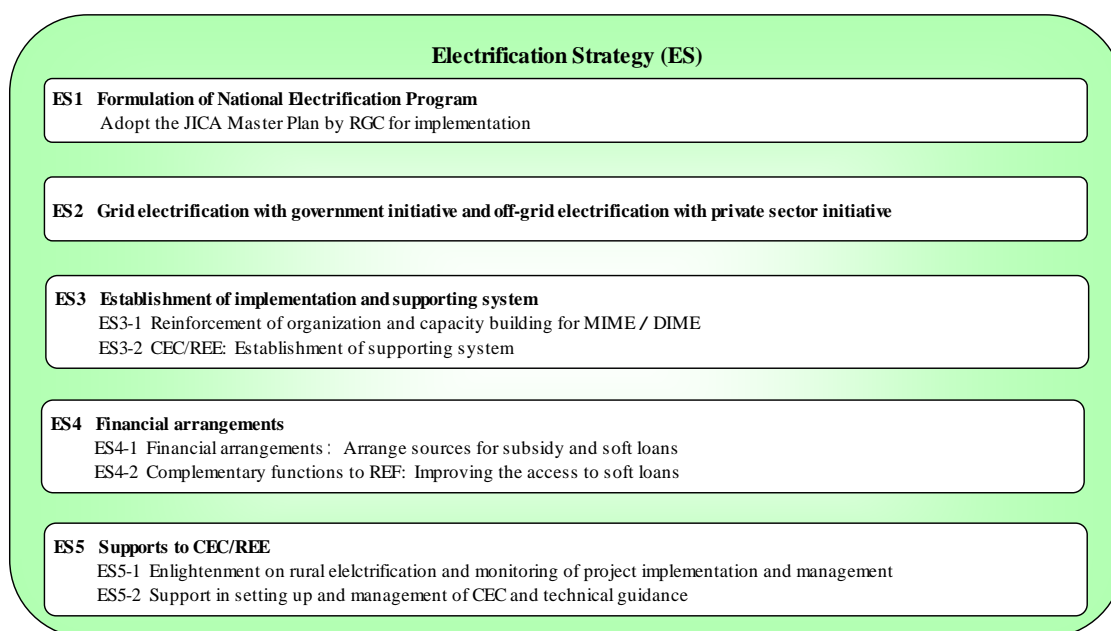
Abbreviation	Description
MEF	Ministry of Economy and Finance
MHP	Micro-hydro Power
MIME	Ministry of Industry, Mines and Energy
MOE	Ministry of Environment
MOI	Ministry of Interior
MOWRM	Ministry of Water Resources and Meteorology
MP	Master Plan
MRC	Mekong River Commission
MV	Medium Voltage
MW	Mega Watt
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

Conclusions and Recommendations

- (1) Policy targets of electrification: MIME sets two targets for the rural electrification in Cambodia:

- 1) To achieve the 100% level of village electrification including battery lighting by 2020;
- 2) To achieve the 70% level of household electrification with grid quality electricity by 2030.

- (2) Electrification strategies: The study team recommends that the following five strategies be employed for promotion of rural electrification:

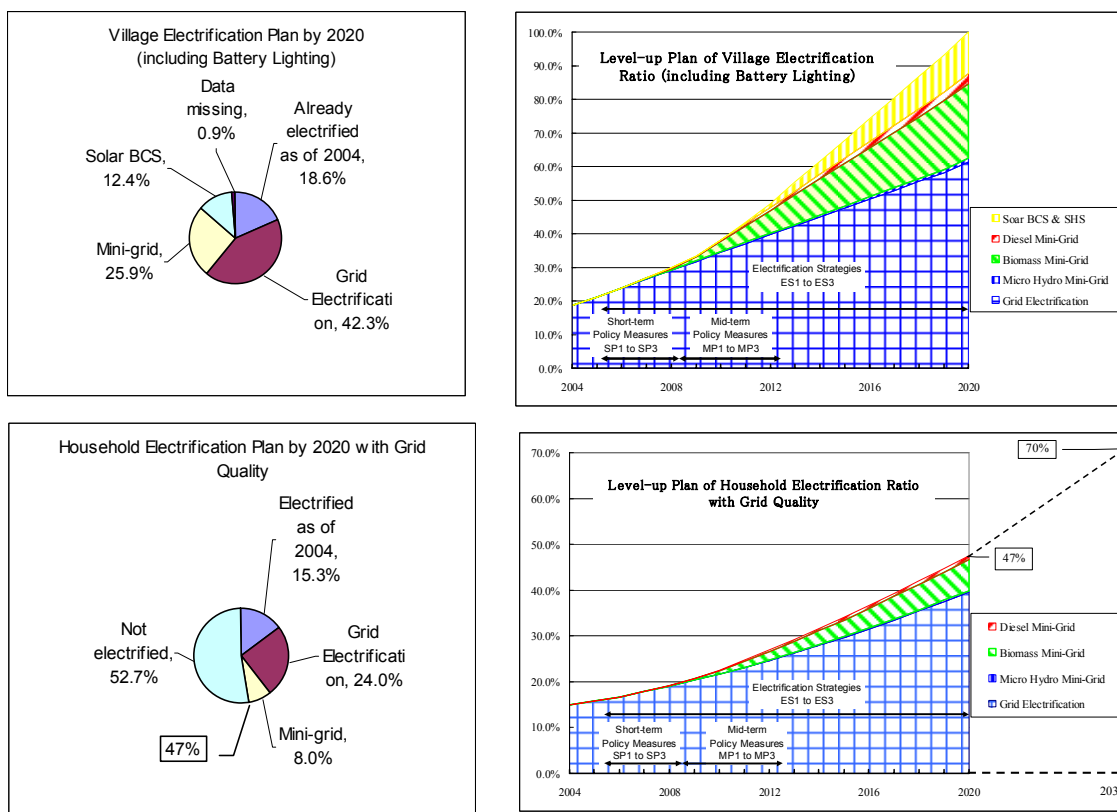


- (3) Electrification plan and financial demand: A total of 272,000 households will be electrified in the off-grid areas by decentralized mini-grids and solar BCSs by the target year 2020. The gross investment costs will amount to about \$147 million.

(Unit: \$ million)

Type of Electrification	Nos. of Villages	Nos. of hh to be newly electrified by 2020	Total Costs	Per hh Costs (\$/h.h.)	Financing Sources		
					Subsidy	Equity	Loan
Grid electrification	6,411	600,000	280	467	70	42	168
Off-grid electrification	5,320	272,000	147	540	54	21	72
Total	11,731	872,000	427	490	124	63	240

- (4) Master plan to achieve the electrification targets: As shown below, the Master Plan has been prepared to achieve the 100% level of village electrification and a 47% level as an intermediate target of household electrification by 2020:



- (5) Recommendations: It is recommended that the following short-term policy measures be implemented as the first step of the Master Plan, to be followed by the mid-term policy measures:

Short-term Policy Measures (SP) (2006-2008)

SP1 Financial arrangements
 SP1-1 Creation of tax exemption system on imports of renewable energy equipment
 SP1-2 Creation of cross-subsidy system

SP2 Preparation for establishing CFR (Complementary Function to REF)
 SP2-1 Improvement of access to soft loans
 SP2-2 Establishment of supporting system to CEC

SP3 Implementation of pilot projects (micro hydro, biomass, solar BCS)

Mid-term Policy Measures (MP) (2009-2012)

MP1 Start operation of cross-subsidy system

MP2 Establish and start complementary functions to existing REF

MP3 Start project implementation in full swing

1. Master Plan Study

(1) The JICA Master Plan Study

The Royal Government of Cambodia (RGC) officially sent a request, in October 2003, to implement a Master Plan (MP) Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia (the Study). In response, minutes were concluded between Japan International Cooperation Agency (JICA) and RGC on June 17, 2004 for implementation of the master plan study, and on August 12, 2004 for the scope of works of the Study. This master plan study has been conducted based on the scope of works.

(2) The Objectives of the Study

The Study aims at formulating an electrification master plan for the off-grid areas with a planning horizon up to the year 2020. The Study is positioned as to complement the electrification by extending the National Grid. The three outputs of the Study are:

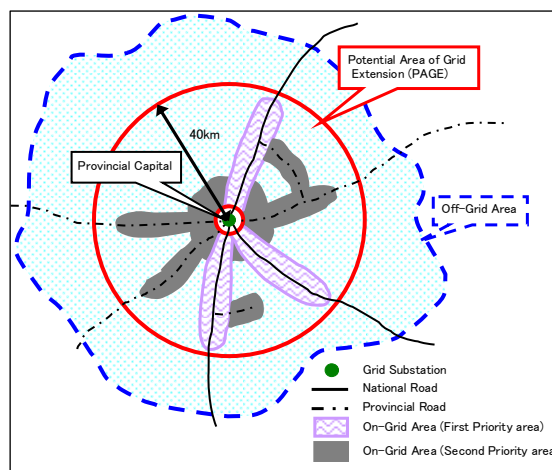
- 1) Master plan on rural electrification by renewable energy;
- 2) Pre-feasibility study on six promising schemes (Pre-FS); and
- 3) Preparation of manuals for MP updating and formulating community electrification plans.

The JICA study team (the study team) jointly conducted a field survey with counterparts from the Ministry of Industry, Mines and Energy (MIME) during the period from the end of November 2004 up to December 2005¹.

(3) The Study Area

The Study covers “the rural areas of the whole Cambodian territory (off-grid area)”, excluding Phnom Penh Municipality, 4 special cities, and the other 20 provincial capitals.

Areas which have been and will be electrified by the National Grid (on-grid areas) and those areas covered by REE licensed from EAC have been excluded from the study area.



Source: JICA study team

Figure 1 Definition of On-grid/Off-grid Area

Figure 1 illustrates the schematic relationship of the on-grid areas and off-grid areas. Light blue colored areas both inside and outside the circle show the off-grid areas which are the target area of the Study. In those areas inside the circle having a radius of 40 km from the provincial capital (PAGE²), extension of the grid lines is technically possible. On the other

¹ During the course of the Study, three National Workshops and three coordination meetings were held with the participation of related ministries (MEF, MIME, MOA, MRD, MOE, etc.), donors (WB, ADB, etc.), DIMEs from all the provinces countrywide, and NGOs.

² Circles with a radius of 40 km from respective provincial capitals are referred to in this report as the Potential Area of Grid Extension (PAGE). EdC has a plan to extend transmission lines toward each provincial capital by 2020 and install an associated grid substation

hand, the areas outside the circle have a low possibility of grid extension by the year 2020. The PAGE for each province is shown on the location map presented at the beginning of this summary.

2. Rural Electrification Master Plan for the Kingdom of Cambodia

2.1 Master Plan

(1) Rural Electrification Goal

The RGC has set ultimate goals for the rural electrification sector as 1) poverty alleviation, 2) improvement of living standards, and 3) development assistance for the rural economy³. As the first step to achieving these goals, MIME has set targets for rural electrification as follows:

- 1) To achieve 100% level of village electrification by the year 2020 including battery lighting⁴; and
- 2) To achieve a 70% level of household electrification by the year 2030 with grid quality electricity⁵.

(2) Present State of Rural Electrification in Cambodia

In the electricity sector of Cambodia, the Electricity Law enacted in 2001 has clearly defined, under the private sector participation and beneficiaries-pay principle, the roles of concerned parties: 1) MIME as policy maker, 2) EAC as regulatory and supervisory agency, and 3) REEs (Rural Electricity Enterprises) to provide electricity supply services. EdC, who constructs and operates the National Grid, is also regarded as one of the REEs. The other private REEs (including Community Electricities Cambodia, CEC) have opportunities to distribute electricity, receiving power from the grid inside the PAGE, as well as to electrify communities in the off-grid areas. In other words, all those living in rural communities should not simply wait for the grid arrival to be implemented by EdC but have equal opportunities to electrify their own communities by self-help. Such electrification policy cannot be found in the neighbouring countries. The study team is of the opinion that such a policy will achieve a significant improvement in the level of rural electrification, if the policy is implemented appropriately⁶.

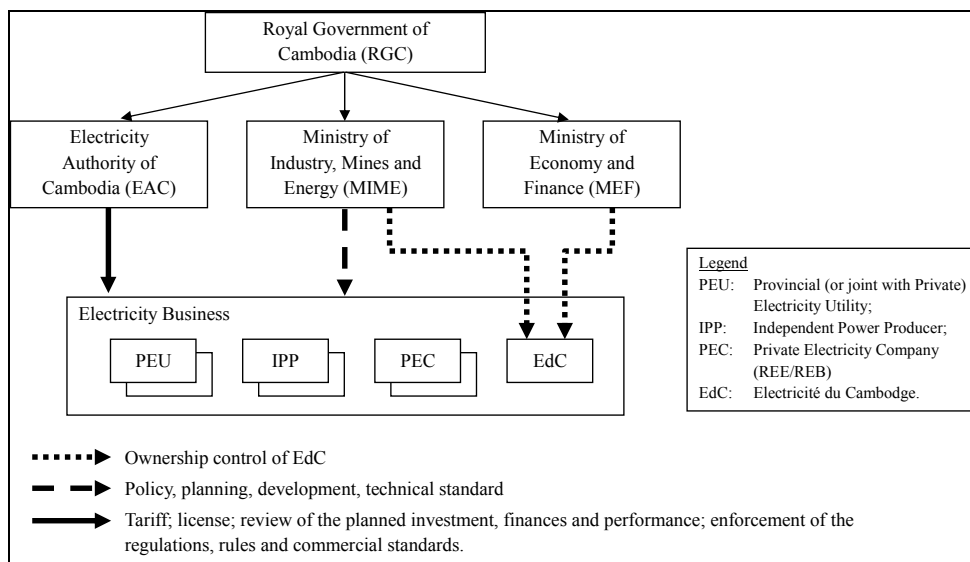
high demand areas will be selected and 22 kV distribution lines will be extended thereto. Most of the communities inside the PAGE will buy electricity from the grid thus extended, and grid electrification in the on-grid areas will become economically and technically possible.

³ "Policy on Rural Electrification by Renewable Energy" in Cambodia.

⁴ MIME's policy paper defines that electrification of one village has been achieved if its level of household electrification including battery lighting is higher than 50%. This criterion of 50% is equivalent to the level that can be considered mature for switching to mini-grids and is, in the opinion of the study team, too high to apply to Level 1 electrification with battery lighting. The study team proposes that it would be more realistic to define the achievement of village electrification at the 25% level of household electrification (1 in 4 households electrified). After achieving the 100% level of village electrification by 2020, the diffusion level of battery lighting will further be improved towards 50%. Then, the villages would be ready to introduce mini-grids or grid electrification. In the MP, it has been planned in accordance with the study team's proposed definition.

⁵ The study team proposes that an intermediate target of household electrification in the year 2020 be set at 47%. The MP has been prepared with this intermediate target.

⁶ Strong points and issues of the electricity sector of Cambodia are presented in Attachment-2.

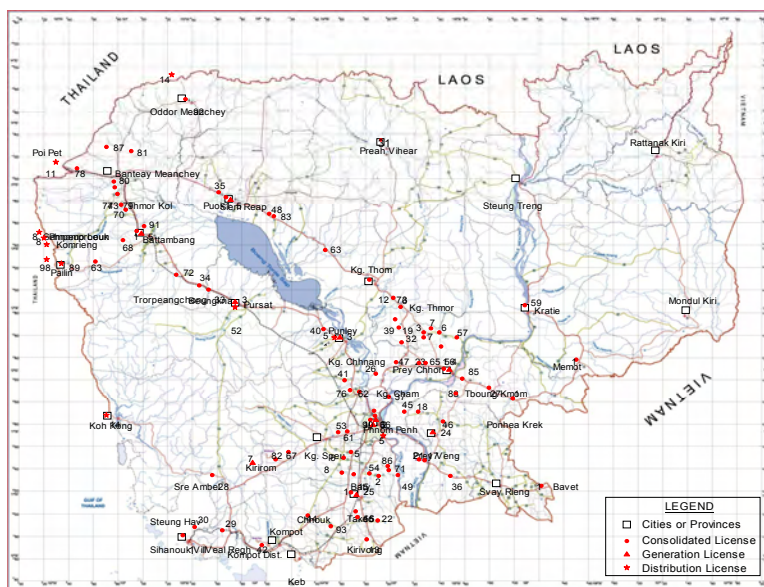


Source: MIME

Figure 2 Organizations of the Power Sector

To promote rural electrification, a Rural Electrification Fund (REF) is under preparation for establishment with assistance by the World Bank as of December 2005. Functions of REF are 25% grant aid and technical assistances for rural electrification projects.

The household electrification level with grid quality electricity as of 2004 was estimated by the study team to be 15.3% including Phnom Penh. Of this, 8.4% is by EdC, 2.9% by REEs, and 4.0% by non-licensed REEs⁷. The electrification level in the off-grid areas, which are those outside the supply areas of EdC, is 7%. In addition to these grid quality electrifications, it is estimated that batteries for home lighting have been installed in 38.5%⁸ of the total households of Cambodia.



Source: EAC

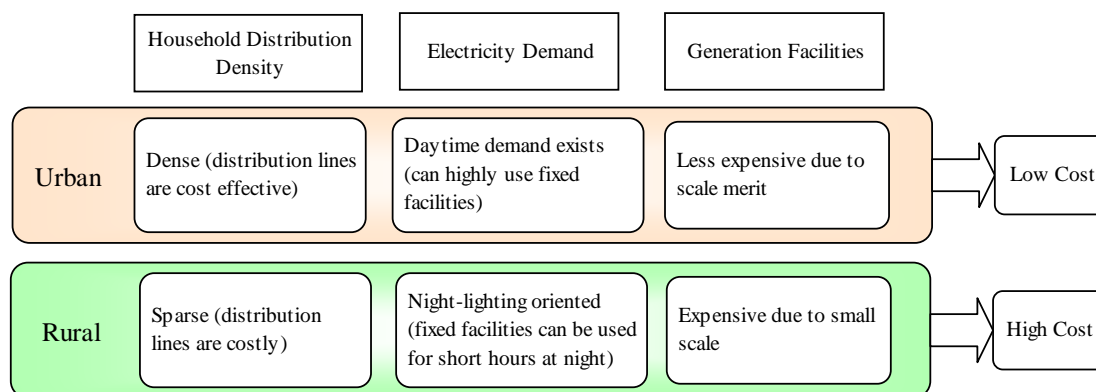
Figure 3 Location of EAC Licensees

As for the mini-grids constructed and operated by REEs, the tariff per kWh amounts to 30 to 90 cents, which is presumably the worlds highest level (REE's operation areas are indicated

⁷ Refer to Table 3.1.1 in Part 1, Vol-2 for details.

⁸ According to a survey by the study team made with DIMES on the level of electrification using a survey form in 2004/2005.

as red marks on Figure 3). As illustrated in Figure 4, rural electrification projects have a destiny of high construction costs due to their small scale and low plant factor (low usage ratio of power generating equipment resulting in a high fixed cost per unit of electricity supplied). As a result of implementing rural electrification projects having such characteristics as a profit business under the same beneficiaries-to-pay principle as in the urban areas, the high tariff has become common in Cambodia⁹. On the contrary, this high tariff could mean that some of the rural people have high ability-to-pay. However, actually about 93% of the rural population do not have access to distribution lines. The gaps between the Phnom Penh residents (enjoying electricity at a subsidized rate of about 9 cents per kWh¹⁰) and the rural people are very large.



Source: JICA study team

Figure 4 Urban-Rural Divide in Electricity Costs

From the result of the electrification level survey to DIMEs, by the study team using survey sheets, around 880,000 households (38.5%) are assumed to have already introduced battery lighting. This household number of 880,000 is greater than the 800,000 households¹¹ planned in the MP for new electrification by grid extension and new mini-grids. Those battery users are estimated to be paying more than \$3 per month if the battery purchase costs are included, and they are considered to have an ability-to-pay for electrification by mini-grids at \$3 to 5 per month.

(3) Basic Approach to Formulating Rural Electrification Program

The present state of the rural electrification in Cambodia described above may be summarized as shown in Table 1 below:

⁹ There is a principle of setting the electricity tariff with the ability-to-pay (ATP), in addition to the principle of beneficiary-to-pay (BTP). However, since no policy measures have been provided to implement the ATP principle, high tariff rates up to 10 times that in Phnom Penh have been actually set and applied (only in the limited number of major towns where people have ATP).

¹⁰ This is a subsidized tariff rate being set at a level lower than the electricity costs. It is applied to those households in Phnom Penh who consume less than 50 kWh a month.

¹¹ This figure does not take account of growth in the household number and population. According to a demand forecast by the study team, the number of electrified households in 2020 will be 1,245,322 and the number newly electrified in 2006-2020 will be 901,285.

Table 1 Present State of Rural Electrification in Cambodia

Grid of EdC	Diesel Mini-grids	Battery Lighting with Diesel BCS
Nos. of household electrified as of 2004 - electrification level		
192,655 hh - 8.4%	157,690 hh - 6.9%	881,904 hh - 38.5%
Present situation and issues		
1) High generation costs of diesel plants	1) High and unstable fuel costs	1) High battery charging costs exceeding \$1.00/kWh
2) Shortage in low-cost generation capacity	2) Poor quality of distribution facilities that causes intolerable voltage drops and frequent black outs	2) Serial charging commonly practiced at commercial BCS, to deteriorate batteries
3) Risk of shortage of fuel supply	3) Shortage in fuel supply during rainy season in particular	3) Over discharging of shallow cycle batteries are commonly practiced at home, to deteriorate batteries
4) Finance for extension of the National Grid	4) Low profitability of small mini-grids that restricts REE participation into rural villages	4) High fuel costs of diesel BCS
5) No official plan of grid extension exists. People cannot know when grid arrives.	5) Inaccuracy of electricity meters	5) Low profitability of small BCS that restricts BCS diffusion to small villages
	6) Lack of concrete poles nearby	
	7) Lack of soft loans	

Source: JICA study team

Bearing the present situation above in mind, the JICA study team proposes the following basic approaches to formulating the rural electrification program of Cambodia:

1) **Maximum Use of Renewable Energy to Secure Sustainability**

The rural electrification program is to be formulated with renewable energy as the main energy source in the off-grid areas from the following viewpoints:

- 1 Economic aspects: Though initial investment cost is high, fuel cost is either non-existent or low compared with diesel generators. Therefore, such electrification projects can be viable on a long-term basis and can contribute to sustainable management owing to absence of need or stable supply of fuel, free from oil price hikes and shortage of fuel supply resulting from international supply-demand balance¹². In addition, with an increase of daytime demand for electricity, the unit generation cost can be gradually lowered.
- 2 Environmental aspects/diversification of energy sources: Clean and renewable, the substitution effect on imported diesel oil (saving foreign currency outflow) and an associated effect of CO₂ emission reduction can be expected.

In view of the renewable energy potential in Cambodia, the energy sources for mini-grids will be biomass in the plain regions and micro-hydro or biomass in the mountainous or hilly regions (refer to Table 5 for potential). If the potential of

¹² The fuel cost hike observed in 2005 put significant pressure on the management of REE's mini-grids. In Siem Reap province, there was an REE that was planning to switch from diesel generator to rice husk power (biomass gasification). In this regard, renewable energy would contribute to sustainable management of mini-grids.

micro-hydro is higher than the demand (village size) and villages exist within an economic distance for transmission from the potential site, micro-hydro will be the most promising energy source.

Solar power will be employed as the energy source for BCSs.

In summary, the following four sources of energy will be employed in the off-grid areas:

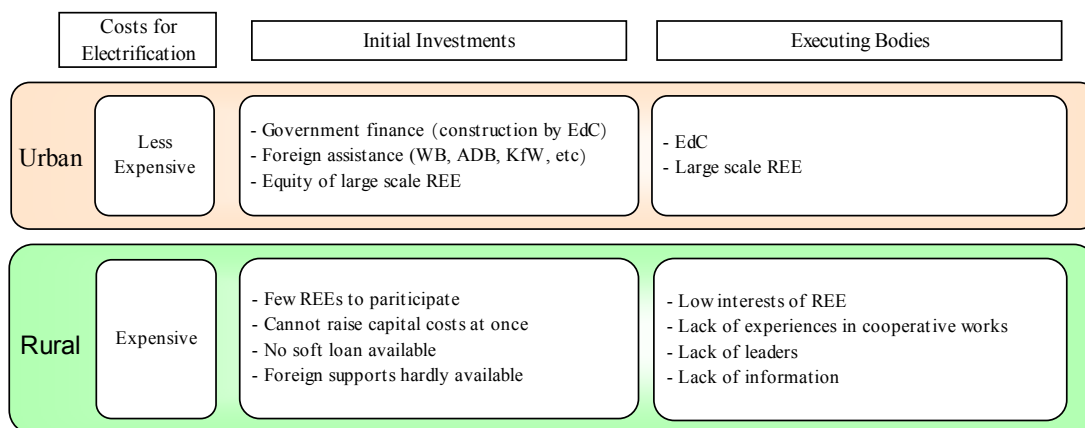
- 1) Micro-hydro power in the mountainous or hilly areas;
- 2) Biomass gasification power in the plain areas;
- 3) Diesel power in those areas that have neither micro-hydro potential nor land for biomass plantations; and
- 4) Solar power for BCSs.

2) Three Levels of Electrification

In order to maximize the level of grid quality household electrification with the limited financial resources available, those villages inside the PAGE and along the main regional roads will be electrified by grid electrification at Level 3; the other remote villages will be electrified by decentralized mini-grids at Level 2 or BCSs at Level 1, depending on the ability-to-pay (refer to Table 4 for the levels of electrification)¹³.

(4) Issues of Rural Electrification Sector

To promote rural electrification in Cambodia, the following issues should be overcome:



Source: JICA study team

Figure 5 Issues of Off-grid Electrification

1) Existence of various studies and plans ⇒ Integration into one National Plan

There exist many studies and plans related to renewable energy and rural electrification as listed below. MIME expects the Study to review these and integrate them into one comprehensive MP.

- Rural electrification master plan and micro-hydro power study by the World Bank

¹³ Penetration levels of battery lighting and TV could be a substitute (indirect) index of ability-to-pay.

- Pipeline Development Program of Small Hydro-power Projects in Cambodia, World Bank/Meritec (2001)
 - Pre-Investment Study of Community-Scale Hydro Projects, Cambodia, New Zealand Ministry of Foreign Affairs and Trade, Meritec (2003)
 - Market survey for SHS by JBIC
 - Feasibility Study on the Establishment of a Centralized Photovoltaic Rural Electrification System, JBIC (March 2004)
 - Renewable energy potential study and field tests by NEDO
 - The Demonstrative Research Project on Dispersed Power Generation Systems (Solar + micro-hydro Hybrid), September 2003
 - Biomass potential mapping and biofuel pilot projects by EU
 - Biomass and biofuel pilot projects by NGOs
 - Biofuel for Sustainable Development and Poverty Alleviation in Rural Cambodia, DATe (March 2006)
- 2) Non-existence of an official development plan for grid electrification ⇒ Two components strategy by grid and off-grid electrification

MIME and EdC have been planning grid electrification including electricity import from neighboring countries, electricity exchange in the GMS (Greater Mekong Sub-Region), a grid extension and distribution extension plans¹⁴. Some of these are under implementation with assistance by the World Bank and ADB as well as private sector participation.

However, an official electrification plan for the National Grid has not yet been authorized. Therefore, people cannot know when distribution lines will come to their community, for those living in rural areas in particular.

- 3) Lack of experience and funds ⇒ Establishment of an implementation and support system
- DIMES develop in all the provinces and many NGOs are engaged in supporting activities for the rural people. However, those NGOs who have experience in rural electrification are limited to only two. Human resource development and arrangement of necessary financial support for such activities are essential.
- 4) High electricity production cost in the rural areas and disparity in the electricity tariff ⇒ Creation of a cross-subsidy system

Disparity between the urban and rural areas is expanding due to the low electricity tariff in the urban areas and the extremely high tariff in the rural areas. As shown in Figure 5, urban people can enjoy government finance, economic cooperation from international developing agencies, and grants with associated tax exemption. When applying the beneficiaries-to-pay principle also to rural electrification, certain complementary measures are required to mitigate the negative aspects of the principle.

¹⁴ Transmission Line Extension Plan for Rural Electrification and Extension Plan of 22 kV Transmission Line are prepared by the Study Team as shown in Figure A-1 and A-2 of Attachment-3.

In relation to this, internal support should not be distributed to urban people who have a relatively higher level of income, with some exceptions, and who enjoy the benefit of electricity generation and distribution facilities constructed with foreign cooperation. These benefits should be expanded and redistributed from the urban people to the rural people (rural electrification projects) who cannot have access to such support.

- 5) No access to loans ⇒ Preparation for establishing loan functions

Through the village surveys and community workshops held as part of the Study, it has been made clear that most of the village people have ability-to-pay (ATP). However, the essential issue is in raising the initial capital costs. It is necessary to create a function of providing soft loans in addition to the existing grant function of REF, in order to provide access to long-term loans with a low interest rate, which complement REF.

- 6) Lack of experience in cooperative work and lack of leaders ⇒ Support to CECs in their setting up and management

Due to the past history of Cambodia in the 1970-80s, people are less familiar with cooperation work. Many villages do not have the human resource to provide community leaders. Further, there are also such people who do not trust and hesitate to contract with REEs from outside the community. It is essential that external facilitators support people in setting up and management of their CEC.

- 7) Lack of information ⇒ Enlightenment on rural electrification program and renewable energy

Many people do not know if rural electrification is possible with local renewable energy. Few people know about biomass in particular. Enlightenment is essential.

(5) Strategy for Rural Electrification

The JICA study team recommends that RGC adopt and implement the short-term¹⁵ and mid-term policy measures presented in Figure 6, in order to achieve the policy goal for rural electrification (refer to paragraph (5) for the electrification strategy and Clauses 2.2 and 2.3 for policy measures).

¹⁵ As for three short-term policy measures, the 1st priority is to establish financial arrangements which RGC can implement itself. Preparation for establishment of CFR (Complementary Function to REF) is the 2nd priority because that needs credit from a foreign country. SP3 Implementation of pilot projects is the 3rd priority because 1) that requires technical and financial assistance from a foreign aid organization, and 2) it is important to implement such pilot projects during Electrification Phase 1 (2005 – 2008).

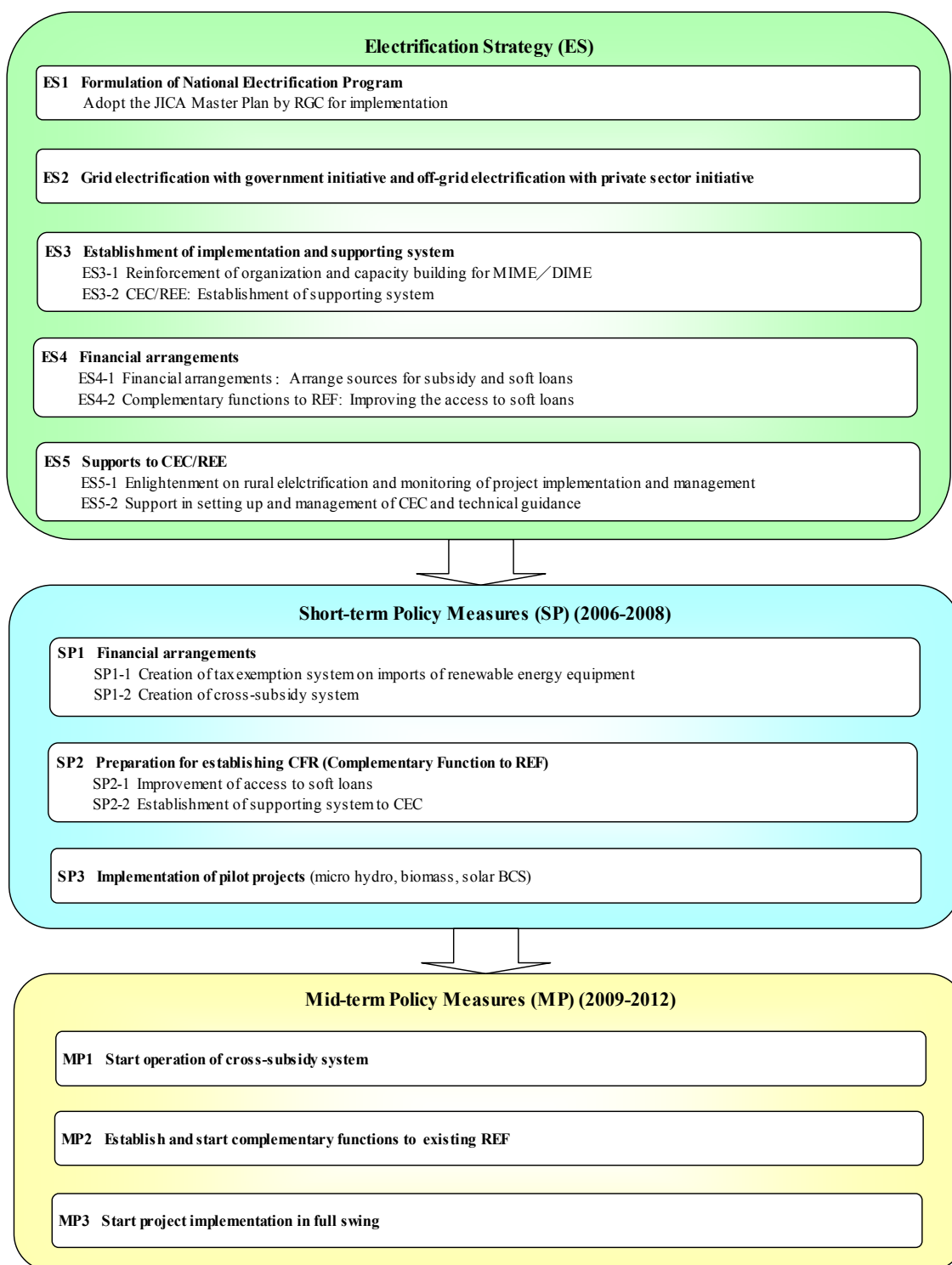
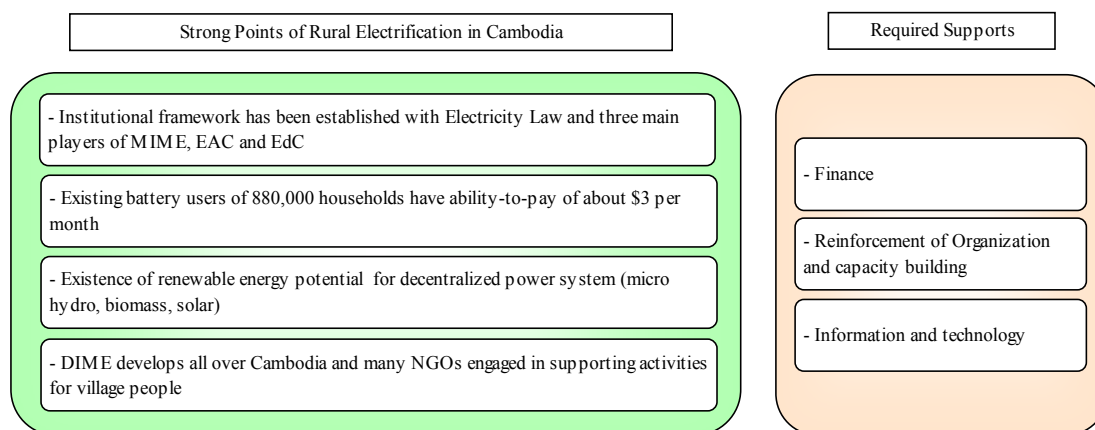


Figure 6 Electrification Strategy, Short-term and Mid-term Policy Measures

ES1 Formulation of National Electrification Program

The MP has been jointly prepared by the counterparts from MIME and the JICA study team conducting field surveys from December 2004 through to December 2005. The JICA study team recommends that the Master Plan be adopted by RGC as the National Electrification Program to achieve the electrification targets.

As shown in Figure 7, the administrative and implementation environments for promoting rural electrification have been created by RGC with support from the World Bank and NGOs contribution to date. The JICA study team has the view that the electrification targets of RGC can be achieved with 1) capacity building and financial support to MIME/DIME and NGOs for respective services to CECs, and 2) with financial support, assistance in setting up and management of CECs, and enlightenment and technical guidance to CECs.



Source: JICA study team

Figure 7 Strong Points and Required Support for Rural Electrification

ES2 Grid Electrification with Government Initiative¹⁶ and Off-grid Electrification with Private Sector Initiative

Rural electrification in Cambodia will be promoted through the following two methods:

- 1) **Grid electrification:** Supply electricity to 600,000 households¹⁷ by the year 2020 through grid extension.
- 2) **Off-grid electrification:** Supply electricity to 200,000 households by the year 2020 with mini-grids. In parallel, provide battery lighting to households in those villages without electricity¹⁸.

As shown in Figure 8, the rural electrification in Cambodia will be driven by two main vehicles. This MP is for the off-grid areas as shown on the right hand side of Figure 8.

¹⁶ EdC may be the main player in extending medium voltage (MV) lines from substations to communes. However, the private sector may also take part in extending MV lines.

¹⁷ This is a figure based on 2.5 million households assumed for 2005 and before including a growth in the population and households to 2020.

¹⁸ A total of 1,720 villages were identified based on the national census 1998 and the Seila village database 2003.

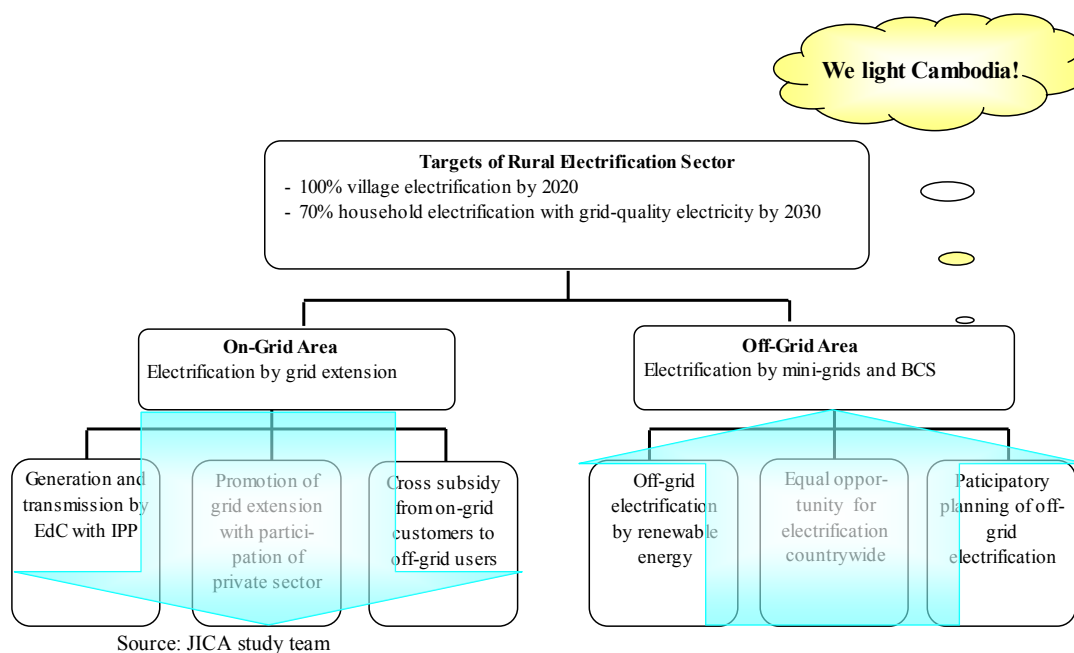


Figure 8 Development Goals and Policy Targets for Rural Electrification in Cambodia

The main targets for the rural electrification promotion are the public (MIME-EdC) for grid electrification, which requires large scale investment, and the private sector (REEs including CECs) for small scale off-grid electrification. In the grid electrification, EdC will extend the National Grid toward provincial capitals and district capitals countrywide by the year 2020¹⁹. REEs will be in charge to distribute electricity on a commercial basis, buying low cost electricity from the grid²⁰.

The off-grid electrification aims at providing equal opportunity for electrification also to those villages that have a low probability in getting extension of the National Grid by the year 2020. The government will enlighten people using the Visual Guide proposed and prepared under the MP, and will be an “enabler” to assist electrification activities, planned and implemented by village people.

ES3 Establishment of Implementation and Support Systems

ES3-1 Reinforcement of Organization and Capacity Building for MIME/DIME

Figure 9 illustrates the organization and main functions of rural electrification sectors in Cambodia. MIME supervises the sector. The REF and its complementary function (hereinafter provisionally referred to as “CFR”) take the role of financial support and provide capacity building.

DIMES are in charge of public relations and the enlightenment of village people. Under the control and support of REF/CFR, NGOs/consultants will be in charge to support the setting up and operation of CECs and to provide technical guidance. The JICA study team recommends that MIME adopt the following three measures for reinforcement of the organization²¹:

¹⁹ Two provinces of Koh Kong and Pailin are excluded from the grid extension plan since these are supplied directly from Thailand.

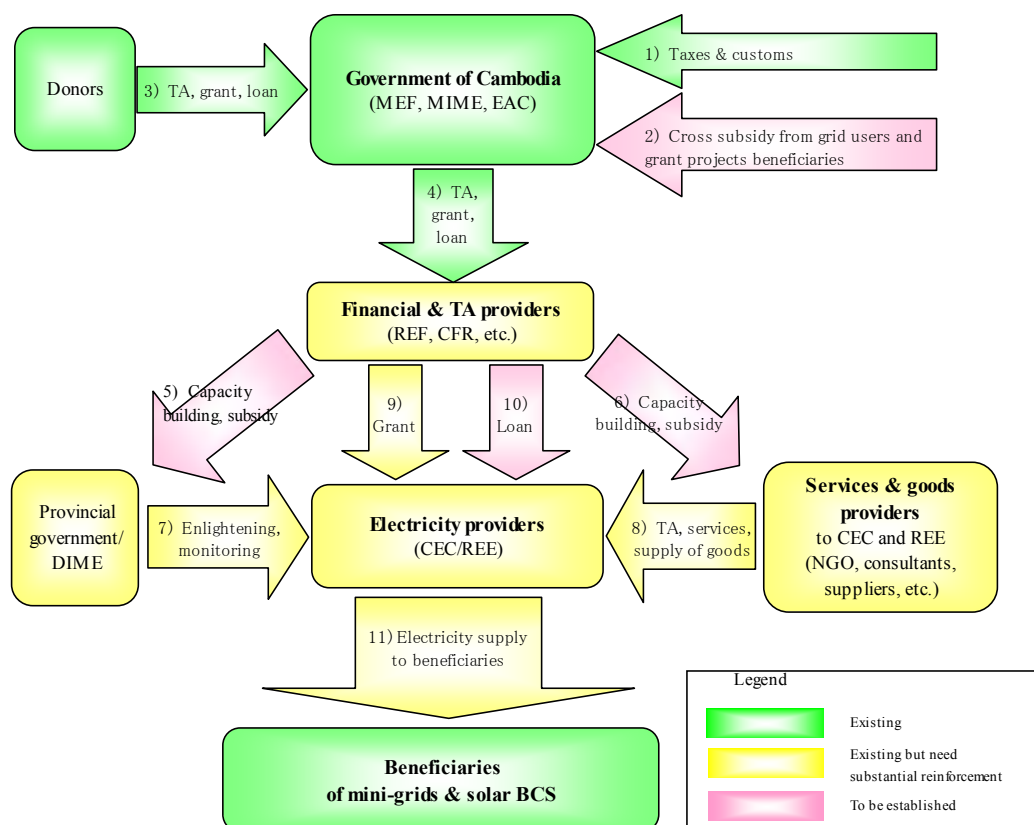
²⁰ The grid extension plan recommended by the study team is presented in Attachment-3, including an extension plan of transmission lines and sub-transmission lines of the National Grid that was prepared aiming at rural electrification.

²¹ Attachment-6 shows the draft plan from the study team for reinforcement of MIME.

- 1) Reinforcement of DIME staff, especially for off-grid area;
- 2) Capacity building of staff; and
- 3) Arrangement of necessary budgets for activities: operational surplus cost from pilot and grant projects, and financial support to DIME for its supporting services to CECs, from REF/CFR through the CECs.

REF/CFR will undertake capacity building and training for “CEC support agencies” like DIMEs, NGOs, and local consultants in the following areas:

- 1) Community workshops;
- 2) Public relations and enlightenment about the National Electrification Program;
- 3) Enlightenment of CECs for establishment;
- 4) Introduction of renewable energy technology;
- 5) O&M and periodical inspection after commissioning; and
- 6) Guidance on accounting, management of reserved money, and auditing.



Source: JICA study team

Figure 9 Agencies and Functions of Rural Electrification Sector

ES3-2 CEC/REE: Establishment of Support System

Two implementing bodies of CEC and REE

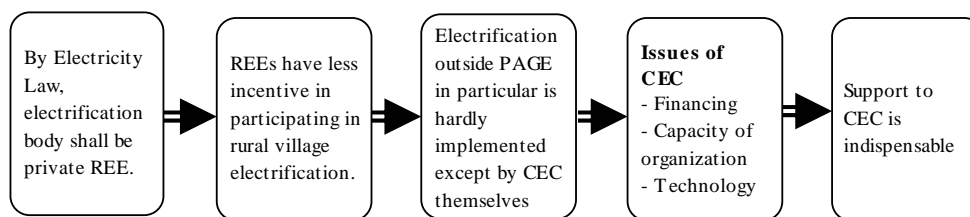
Due to the limited ability-to-pay (3 to 5 dollars per month) of rural households and limited

number of capable REEs (107 licensed REEs as of 2004), the study team recommends that the following two methods for project implementation be employed:

- 1) To electrify as many villages as possible with the minimum financial support to REEs; and
- 2) To electrify those less profitable rural villages with various support to CECs.

Figure 10 shows the background of the necessity for implementation of electrification projects using CEC groups and the necessity for external support. As for off-grid electrification demand, there are more than 3,000 villages only as mini-grid candidates. In these target villages it is supposed that battery lighting has penetrated to more than 50% of households, and people are supposed to have the ability to pay \$3 to \$5 per month. But, if promotion of such electrification projects just relies on private REEs based on the market principle, promotion of electrification would be limited to only local big cities. There would be slow or hardly any progress with electrification in other villages. This is due to low profitability and limitation of numbers of capable REEs. As EdC needs to concentrate on grid extension, if villages just wait for such grid extension to come, such villages will never know when such a grid extension will come to the village. In this connection, in order to realize early electrification by mini-grids, it is necessary for community residents themselves to establish a CEC, with self supportive efforts, preparing initial equity, and taking risks, to implement less costly electrification.

Figure 10 shows the background of the need for CEC support.



Source: JICA study team

Figure 10 Background of Need for CEC Support

Electrification by CEC mini-grids is the priority method for maximizing the number of households electrified in the off-grid areas²². As to the REE mini-grids, those that are profitable projects will be implemented by the market mechanism with a minimum of financial support.

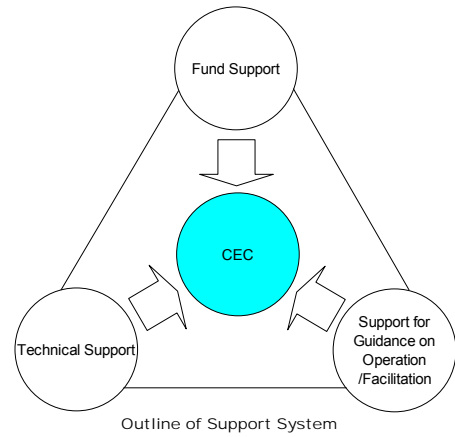
For solar BCSs, a lease charge will be levied to the CEC and pooled in the CFR mainly to monitor and finance the maintenance costs of such BCSs. Solar BCSs would be a main driving vehicle to achieve the 100% target of village electrification. However, in view of its high equipment cost and the low ability-to-pay of the users, installation of BCS equipment by CECs will hardly be possible and will require a grant. Therefore, operation should be by CEC not REE²³.

²² Because of the low ability-to-pay and low trust of REEs by the people, it is anticipated that a significant number of communities would prefer adopting the CEC system that has the possibility to achieve a lower electricity tariff compared to that of the REE system. In the Community Workshops held 10 times in December 2005, 8 out of the 9 communes desired the CEC system due to their low trust of REEs, although the people recognized their own difficulties in initial fund raising.

²³ As for SHS, some sales models for dispersion can be seen in other countries such as *sales models* and *service models*. With such models, without a high ratio subsidy or soft loan, beneficiaries would be limited to a rich layer on the top level of the income pyramid. In the case of BCSs, they will be introduced by CECs or rural rich people in the village. However, due to its high capital cost compared with a diesel BCS, there would be little incentive to the private sector for introduction of a solar BCS in small villages.

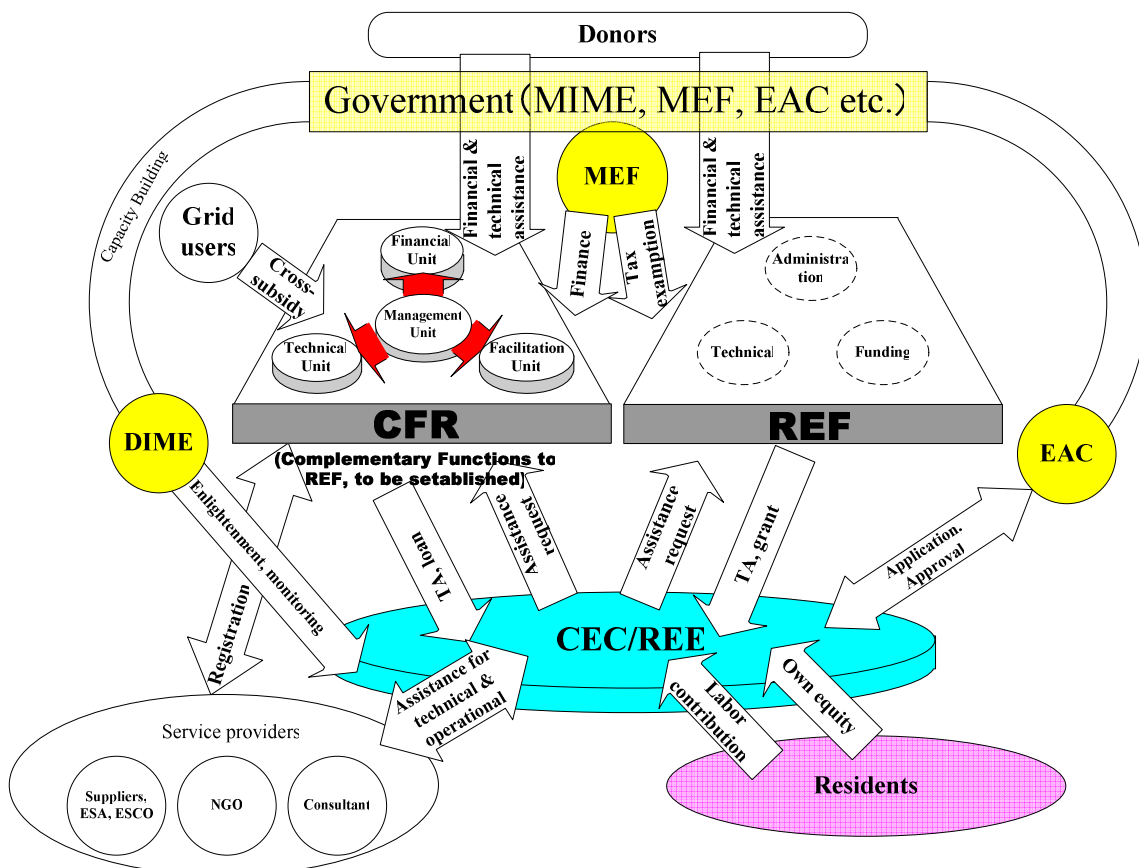
Support in setting up and management of CECs

Three elements of the CEC support system are shown in Figure 11 and their frameworks are shown in Figure 12 (refer to Table 3 for functions of respective agencies). Figure 13 illustrates a concept of the support for CEC setting up and management²⁴.



Source: JICA study team

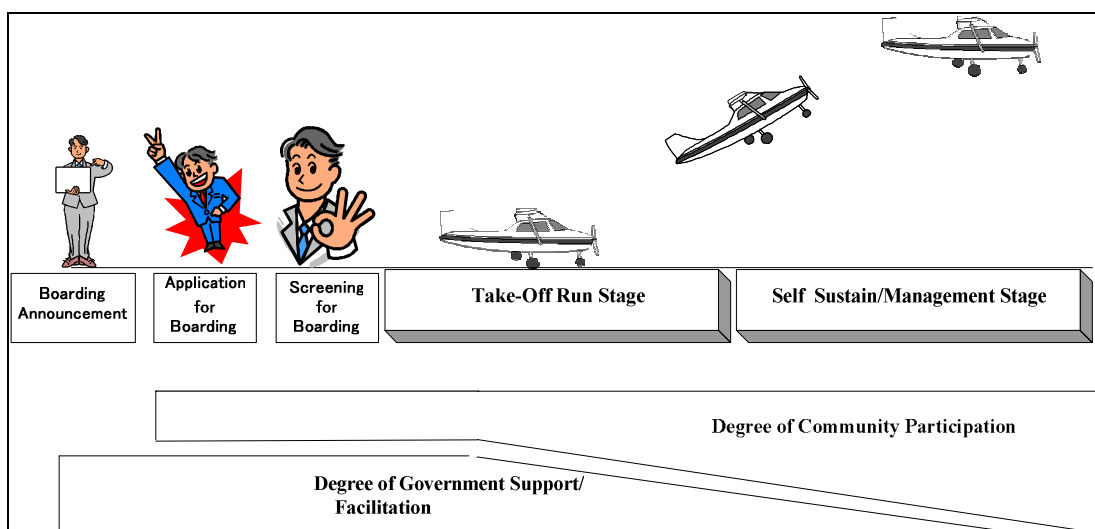
Figure 11 Three Supports to CEC



Source: JICA study team

Figure 12 Framework of CEC Support

²⁴ Attachments 4 and 5 outline the results of Community Workshops held in 10 communes in December 2005, and the conditions required for achieving sustainable management by a CEC. Further, details of CEC supporting work are presented in Attachment-9.



Source: JICA study team

Figure 13 Concept of CEC Support

- 1) Boarding announcement by DIME (enlightenment with Visual Guide, public relations of the supporting system)
- 2) NGO/consultants to support in “application for boarding” to “take-off run” stages (setting up of CEC, fill-in the application form to REF/CFR, implementation of projects, commencement of operation)
- 3) Monitoring by DIME after shifting to horizontal stable flight (periodical check once a year, monitoring of operation and maintenance, and checking accounting)

ES4 Financial Arrangement

ES4-1 Financial Arrangements: Arrange Sources of Subsidy and Soft Loans

It is necessary for MEF/MIME to arrange finance of about \$427 million from the sources described below. Of these about \$147 million are required for the off-grid area.

Table 2 Summary of Financing Requirements to Year 2020
(Unit: \$1,000)

Type of Electrification	Total Costs	Fund Sources		
		Subsidy	Equity	Loan
Grid electrification	280,140	70,035	42,021	168,084
Off-grid electrification	146,887	54,219	20,903	71,764
Total	427,027	124,254	62,924	239,848

Source: JICA study team

Potential sources of subsidy

- 1) Tax exemption on imports of renewable energy equipment (equivalent to financial support of \$13 million in total from 2009 to 2020);
- 2) Cross-subsidy from the grid users (\$40 million scale in total from 2009 to 2020);
- 3) Operating surplus of the pilot projects after deducting expenses and reserved money for future maintenance and replacement, and service fees from CEC for supporting activities (these are to be used for supporting activities by MIME/DIME); and
- 4) Grant from donors, equity capital contribution in-kind (grant projects)²⁵.

²⁵ The study team proposes that an amount equivalent to a tariff surcharge to the grid users be collected, including those beneficiaries of grant projects, and that these be allocated to MIME/DIME for their support activities to CECs.

Potential sources of soft loans

- 1) Government revenue of MEF; and
- 2) Soft loans/equity capital from donor agencies.

ES4-2 Complementary Functions to REF (CFR): Improving the Access to Soft Loans

To complement the supporting framework of REF, long-term loans with low interest rates are required. The functions of the existing REF are, by its establishment decree, limited to grant and TA functions only. Therefore, the study team recommends that a new financing scheme (a kind of special account or a Special Purpose Company (SPC) with a non-profit basis, which can be called Complementary Functions to REF; herein provisionally abbreviated as CFR) with a loan-providing function, be established under the control of MEF-MIME.

Loans available from commercial banks are with interest rates of 20 to 30% at the best with a repayment period of 1 to 2 years at the longest. In addition, a large amount of collateral is required. For these reasons, commercial bank loans have been used only in such projects as diesel BCSs or diesel mini-grids of which the initial investment is relatively small and the investment recovery period is short.

However, renewable energy needs a large initial capital and needs a longer period to recover the investment²⁶.

ES5 Support to CEC/REE

ES5-1 Enlightenment on Rural Electrification and Monitoring of Project Implementation and Management

For general administration and management activities such as enlightenment, checking, and auditing, it is proposed to appoint DIME²⁷. The population density in Cambodia is low and the condition of the rural roads and telecommunications are bad. Under such conditions, in order to control and monitor the progress and situation with rural electrification projects countrywide, and in the off-grid areas in particular, appointment of staff from local governments and DIME, stationed in each province, will contribute to efficient use of time, money and staff. Dispatch of NGOs, consultants and suppliers from Phnom Penh on an on-demand basis would require much more time and cost for mobilization, so timely and efficient services are hardly achieved.

A subsidy to a CEC/REE will be remitted to a CEC/REE bank account. A certain part of the subsidy can be used only for such technical support and administrative services to be provided by DIME, NGO, etc. in accordance with provisions included in a support agreement with the REF/CFR. In parallel with the project progress, the CEC/REE submits necessary documents and the costs for technical support and administrative services are paid directly to DIME or the NGO from the bank account of the CEC. Such payment schemes from CEC to external facilitators are to be incorporated into the support system.

DIME will provide the following services to the CEC on a cost plus fee basis:

²⁶ A trial estimate of the study team shows that in the case of biomass power generation, initial capital costs can be recovered with a tariff rate at about 35 cents/kWh if it is financed with 15% CEC's equity capital, 25% subsidy, and 60% loan (interest rate 3%, 15 year period) on top of tax exemption.

²⁷ To support a CEC in its setting up and management, repair and maintenance of equipment, such expert organizations in respective fields as NGOs, EdC, suppliers, etc. will be mobilized.

- 1) Services to BCSs such as patrol tour for periodical inspection and maintenance, guidance, and account auditing on behalf of CFR. The charges will be paid from the reserved money from the lease charge of the BCS²⁸.
- 2) Services to mini-grids such as patrol tour for periodical inspection and maintenance, guidance, and account auditing²⁹ on behalf of CFR until full repayment of the loan. The costs will be paid from the operating reserve for such purposes.

ES5-2 Support in Setting up and Management of CECs and Technical Guidance

Communities that desire electrification need to have a community workshop in line with the Visual Guide prepared under this master plan study to carry out the following items:

- 1) Confirmation of willingness for electrification by beneficiaries-to-pay
- 2) Selection of implementation bodies (REE or CEC).

In the case of implementation by CEC,

- 3) Establishment of CEC, registration, demand survey, formulation of electrification plan, saving for initial equity, preparation of application form for fund support
- 4) Design, procurement, construction, test, obtaining REE license from EAC, payment to assistance providers/experts
- 5) Operation and maintenance, management of electricity business, repayment of loan³⁰, payment of license fee, preparation of accounting report, replacement of equipment.

Table 3 summarizes supporting agencies and functions required in planning, implementation and management³¹ of rural electrification projects by CEC.

²⁸ In the case of BCSs, patrol inspection of the BCS will be undertaken by DIME for 1 night and 2 days on average. Its services cost is estimated at \$67 on average (\$10-\$40 for transportation, \$15 for lodging, and \$6 x 2 days as allowance). When it is judged that the repair works required are beyond the technical capacity of DIME staff, it will be reported to a supporting agency (CFR). CFR will dispatch suppliers, who will be paid for their services out of the reserved leasing charges of the BCS managed by CFR (\$200/year/BCS of average capacity at 1.14 kWp).

²⁹ EAC have been providing similar services to REEs as the regulatory body of the power sector. The auditing etc. by DIME should not interfere with such activities of EAC but should be undertaken from the position of the CFR as loan provider in coordination with EAC in order to achieve the maximum support to the CEC.

³⁰ Acleda Bank has the maximum number of branch offices in rural areas. After opening a bank account in the name of the CEC in those branch offices, the account can be used for fund transmittal from supporting agencies in Phnom Penh, and also for transmittal of loan repayments.

³¹ Micro-hydro requires expert know-how. It is difficult for a CEC to plan and implement it. MIME/DIME should be a main implementing body of micro-hydro. It is necessary for them to have technical assistance, mainly in building technical and management capacity.