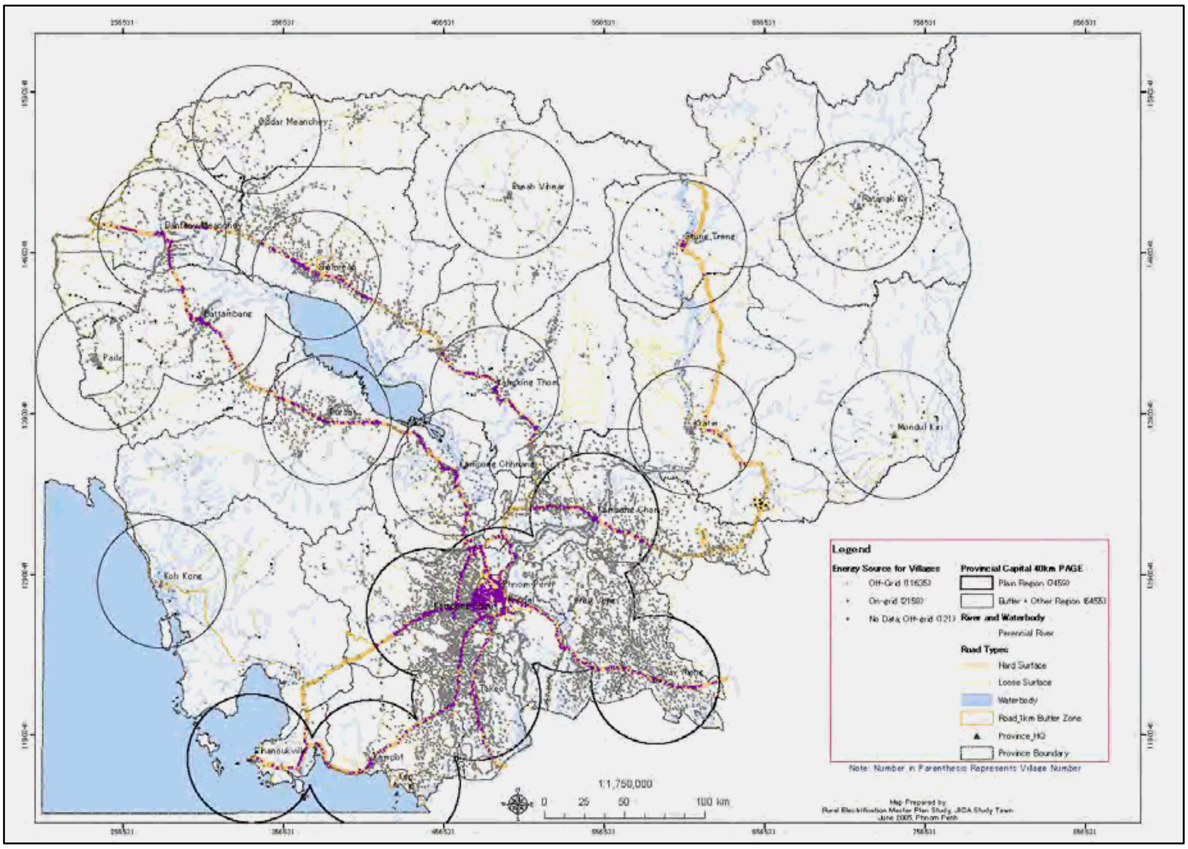
2.2 RURAL ELECTRIFICATION POLICY OF OFF-GRID AREAS

2.2.1 Strategy of Electrification in the Off-Grid Area

(1) The Off-Grid Area

The on-grid area assumed as of 2008 is shown in Figure 2.2.1.



Source: JICA Study Team

Figure 2.2.1 PAGE, On-grid Area and Off-Grid Area

It will be electrified following completion in 2007 of the RE&T project (financed by WB and ADB), which will establish a 220 kV line from Vietnam to Phnom Penh to import low cost energy up to 200 MW (refer to Sub-section 2.1.1 hereof for 115 kV lines to import 160-240 MW in total from Thai and Laos). The imported power of 360-440 MW in total will be sufficient as the energy sources for the grid electrification countrywide, estimated at 195 MW (see Table 3.2.1 of Part 1).

The off-grid area is the target area of the Master Plan. Referring to the national grid extension plan of MIME, the Potential Area of Grid Extension (PAGE) is drawn as a circle with a radius of 40 km and centers at each provincial capital (see Figure 1.3.1 for definition). The off-grid area consists of the area outside PAGE and those areas inside PAGE but excluding the on-grid area. The off-grid area will decrease along with yearly expansion of the on-gird area.

The distance 40 km is a technical limit of 22 kV distribution lines in practical engineering viewpoint to transmit power from grid substation (GS) to customers also taking account of the future growth in the unit demand. GSs will be established in each provincial capital and connected to the national grid. More than 80% of the villages and households in Cambodia are situated inside PAGE. Therefore the grid extension is allocated with the principal role in the rural electrification. However, the grid extension requires a great amount of capital and needs long time for reaching villages situated outside PAGE or apart from roads even inside PAGE. Therefore the grid extension, if not combined with the off-grid electrification, would even expand the current socioeconomic disparity between urban and rural until completion of the nationwide national grid, which would be beyond 2030.

Primary areas of grid electrification are set as 1 km wide zones along and on both sides of the national roads Nos. 1 to 7. The width of 1 km is a technical limit of LV distribution lines. Only in these zones alone, there are more than 210,000 non-electrified households. This number corresponds to 2/3 of the 310,000 households existing in the service area of EdC as of 2004. New grid electrification areas will be added to the on-grid area whenever EdC prepares extension plan of 22 kV lines in each province.

(2) Electrification Concept of the Off-Grid Area

In the Master Plan, two methods of rural electrification are employed: one is the grid extension (grid electrification) and the other the electrification with decentralized mini-grids and BCS (off-grid electrification). The three leveled electrification concept of the Master Plan is presented below:

RE Level 1 targets diffusion of battery lighting by installing solar BCS with government finance aiming at poverty alleviation in remote areas. This electrification by solar BCS is a tool recommended in the Master Plan to achieve the policy target of 100 % village electrification by 2020.

RE Level 2 targets electrification for lighting, TV and so force with an average power consumption at 100 W per household. The lowest demand could be around 30 W in those remote poor villages where people can marginally pay tariff for lighting but cannot afford to buy TV. It would increase towards 200 W in those villages located near provincial capitals or national roads or blessed with agricultural products where people can pay not only for lighting and TV but also to buy electric fan, iron, rice cooker, hot water pot, and so forth. Existing mini-grids are in general designed with 100 W per household and 7-10 kWh per household per month. In some existing mini-grids, the power consumption exceeds 100 W to require more power capacity. However, average energy consumption can hardly exceed 10 kWh per household per month. In the Master Plan, the power demand is set at 100 W on a nationwide average with a range from 30 to 200 W.

In the mini-grid, users are required to limit the electricity use only to the agreed and committed level of consumption at the time of initial planning of the generation capacity and financing. Use of high load appliances like irons and electricity stoves should be prohibited unless declared and committed for payment at the planning stage. In view of the high generation costs of mini-grids at $0.40-0.50/kWh, it is recommended to limit the consumption until the grid connection (RE Level 3). If users wish to use such heavy loading appliances in excess of the agreed load limit, they should introduce own generator set or wait for the grid connection.

RE Level 3 is the grid electrification. People can use any kind of electric appliances. Power tariff will be much low ($0.09-0.15/kWh in the EdC grid in 2005).

(3) Why Mini-Grids and BCS in Addition to the Grid Extension?

The basic strategy of the Master Plan is to promote the electrification of Cambodia in the following way:

(i) In the on-grid planning area, EdC will implement the grid electrification including connection of sub-grids owned and managed by REE in accordance with its yearly extension plan of 22 kV lines.

(ii) In the off-grid area, RE Level 2 electrification will be realized earlier by introduction of mini-grids than simply waiting for arrival of the grid extension above. With the mini-grids people can enjoy life with lighting and children can read a book at home.

(iii) In the remote poor villages, people can also have a life with battery lighting with solar BCS. The battery lighting in these villages is the first step towards poverty reduction through improving the level of literacy currently below 50%.

The grid electrification spreads step by step from urban to rural. In most villages except for those located along the national roads and major regional roads, people may have to wait for arrival of the grid extension for 10 to 20 years or even more, in proportion to the distance from Phnom Penh or provincial capitals.

One mini-grid for 200 households, for example, costs about US$ 100,000, which can split bulk capital needs of grid extension into small pieces. This provides also villages in the off-grid area with *Equal Opportunity* for electrification.

(4) Features of Off-Grid Electrification

The principal feature of mini-grids and BCS is that these can be established irrespective of the relative location to provincial capitals and the national grid. If people do wish to have their own villages electrified with a spirit of self-help under a supporting program of the Master Plan, it is possible to install either mini-grids or BCS in any village allover the country.

Mini-grids will sooner or later be connected to the national grids by 2030 except for those located outside PAGE. The mini-grids located inside PAGE should be designed to meet the standards of EAC, which will include in the future some options suitable for mini-grids. The mini-grids meeting such standards can be used also after the grid connection.

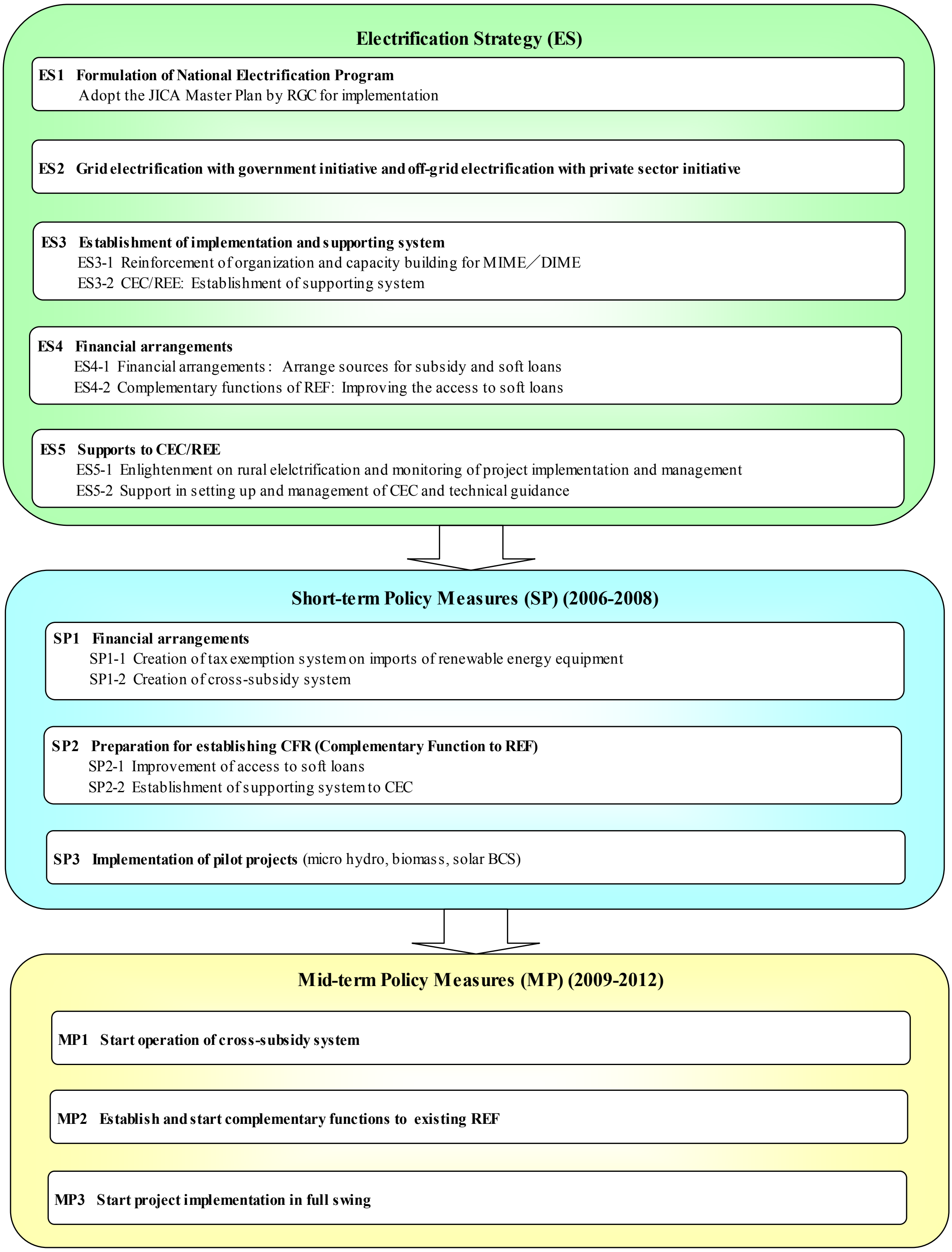
After the grid connection, generating equipment can be either:

1) scraped if it has been depreciated and its lifetime is over;
2) sold in the market or shifted to non-electrified villages if it can still work; or
3) keep it and continue power generation and sell extra electricity to EdC (new institution is required to facilitate such electricity trade between the EdC grid and mini-grids).

Therefore, investment on the distribution lines will incur no particular loss upon the grid connection even if it is realized in a few years after the commissioning of the mini-grids. Also, no specific loss in the generating equipment would result from the grid connection.

(5) Strategy for Rural Electrification

The JICA study team recommends that RGC adopt and implement the short-term and long-term policy measures presented in Figure 2.2.2, to arrive at the policy goal of rural electrification.



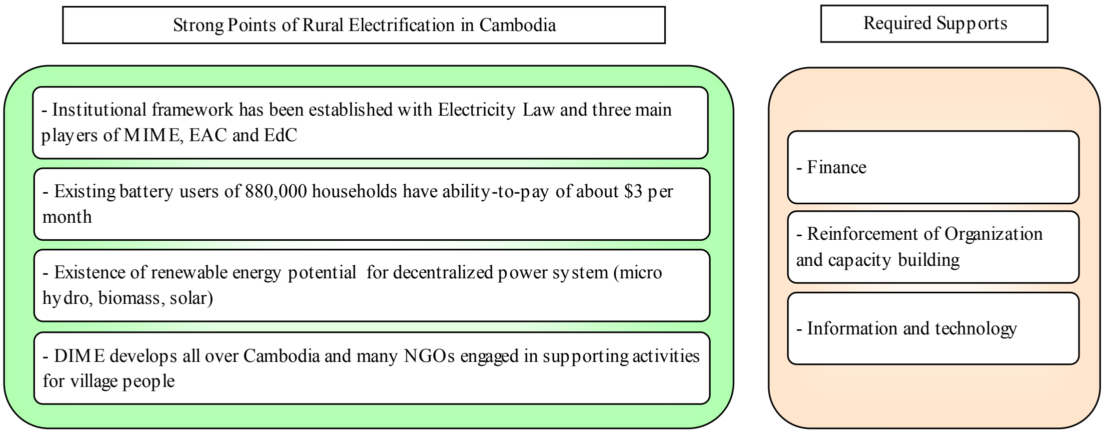
Source: JICA study team

Figure 2.2.2 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 2.2.3, 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 supports to MIME/DIME and NGOs for respective services to CECs; and 2) with financial supports, assistance in setting up and management of CECs, and enlightenment and technical guidance to CECs.



Source: JICA study team

Figure 2.2.3 Strong Points and Required Supports for Rural Electrification

ES2 Grid Electrification with Government Initiative 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 households[1] 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 electricity[2].

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 2020[3]. REEs will be in charge to distribute electricity on a commercial basis buying low cost electricity from the grid[4].

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 Supporting Systems

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

Figure 2.2.4 illustrates the organization and main functions of rural electrification sectors in Cambodia.

1 This is a figure based on a 2.5 million households assumed for 2005 and before including a growth in the population and households to 2020.
2 A total of 1,720 villages was identified based on the national census 1998 and the Seila village database 2003.
3 Two provinces of Koh Kong and Pailin are excluded form the grid extension plan since these are supplied directly from Thailand.
4 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.

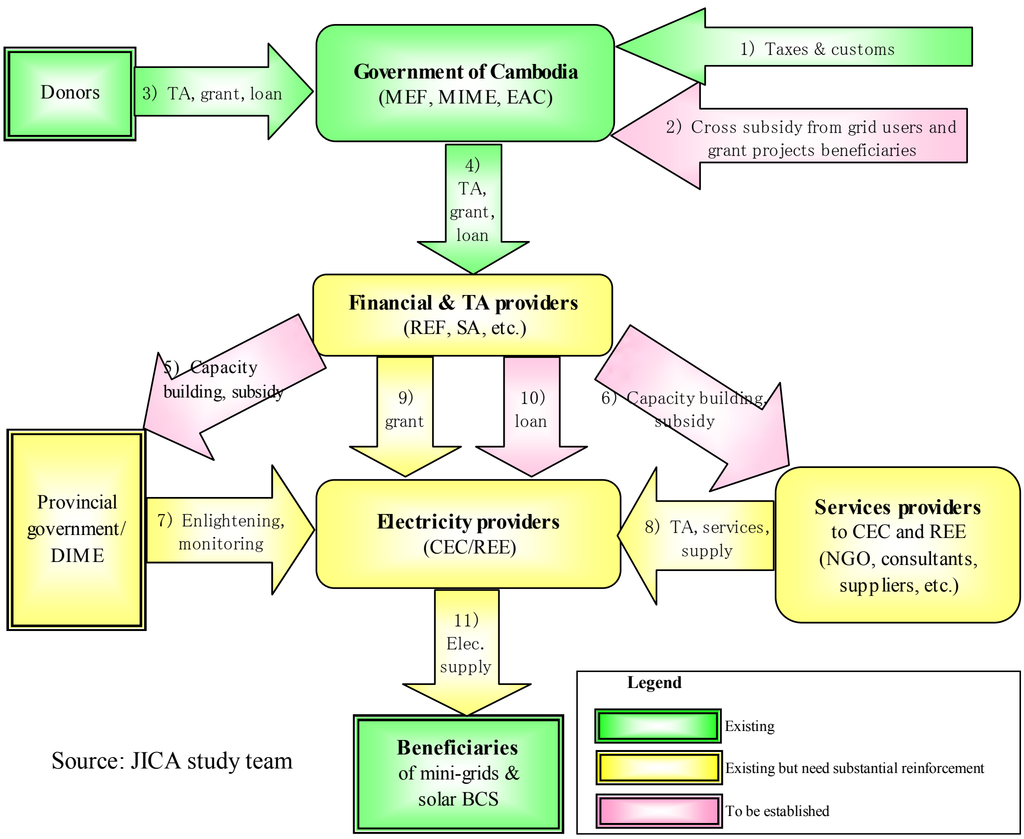
MIME supervises the sector. The REF and its complementary function (hereinafter provisionally referred to as "CFR") take the role of financial support and provide capacity building.

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 organization[5]:

1) 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 to "CEC supporting agencies" like DIMEs, NGO, 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 2.2.4 Agencies and Functions of Rural Electrification Sector

[5] Attachment-6 shows draft plan of the study team for reinforcement of MIME.

ES3-2 CEC/REE: Establishment of Support System

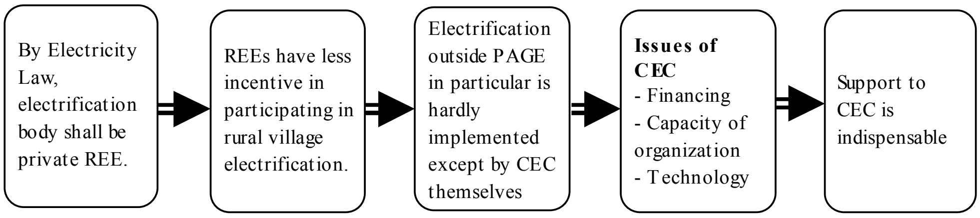
Two implementing bodies of CEC and REE

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 2.2.5 shows the background of the needs to CEC supports.



Source: JICA study team

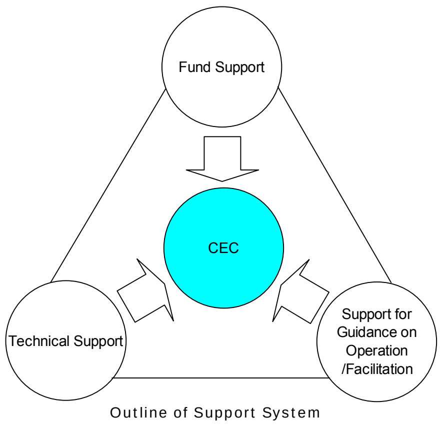
Figure 2.2.5 Backgrounds of Needs to CEC Supports

Electrification by CEC mini-grids is the priority method for maximizing the number of households electrified in the off-grid areas . 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 REE[7].

Support in setting up and management of CECs

Three elements of the CEC support system are shown in Figure 2.2.6 and their frameworks are shown in Figure 2.2.7. Figure 2.2.8 illustrates a concept of the supports for CEC setting up and management[8].



Source: JICA study team

Figure 2.2.6 Three Supports to CEC

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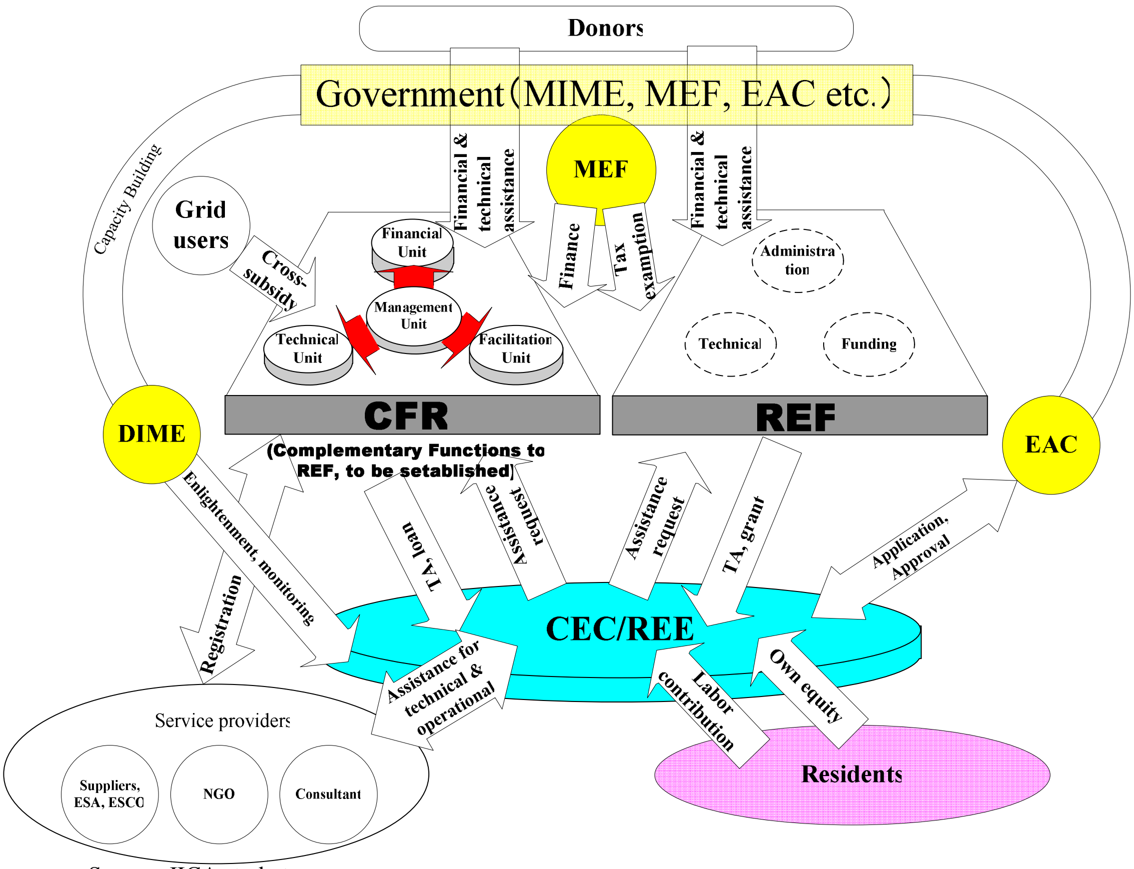
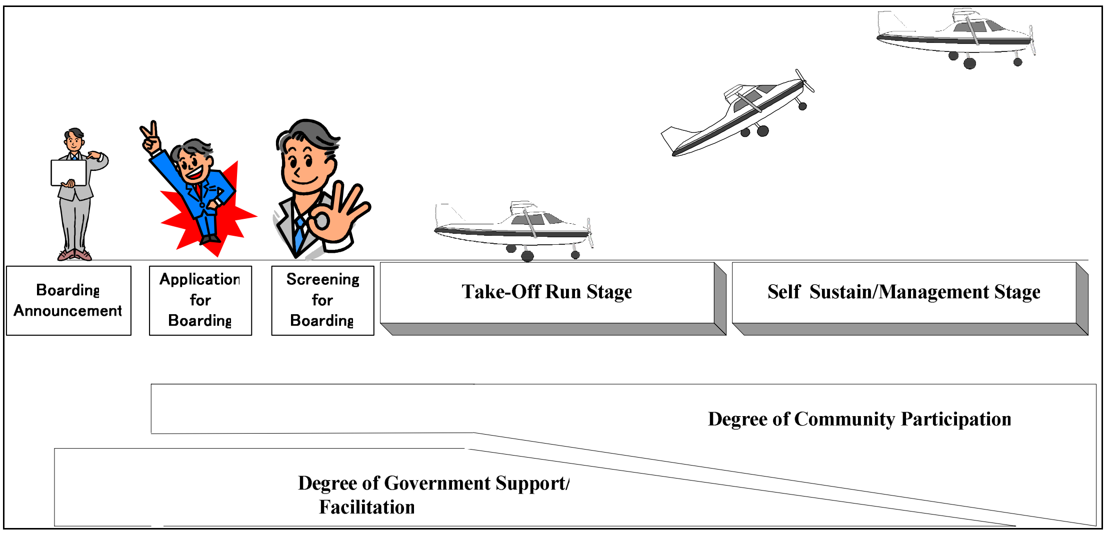
7 As for SHS, some sales models for diffusion can be seen in the other countries such as *sales models* and *service models*. With such models, without high ratio subsidy or soft loan, beneficiaries would be limited to a rich layer on the top level of the income pyramid. In the case of BCS, it will be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

8 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 CEC. Further, details of CEC supporting works are presented in Attachment-9.



Source: JICA study team

Figure 2.2.7 Framework of CEC Support



Source: JICA study team

Figure 2.2.8 Concept of CEC Supports

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 2.2.1 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)[9].

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: 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 investment [10].

[9] 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.

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 DIME [11]. 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:

1) 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 BCS[12].

2) Services to mini-grids such as patrol tour for periodical inspection and maintenance, guidance, and account auditing[13] 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:

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10 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.

11 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.

12 In the case of BCS, patrol inspection of BCS will be undertaken by DIME for 1 night 2 days on an average. Its services cost is estimated at $67 on an 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 his services out of the reserved leasing charges of BCS managed by CFR ($200/year/BCS of average capacity at 1.14 kWp).

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

17 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.

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 loan[17], payment of license fee, preparation of accounting report, replacement of equipment.

Table 2.2.2 summarizes supporting agencies and functions required in planning, implementation and management[18] of rural electrification projects by CEC.

Table 2.2.2 CEC Supporting Agencies and Respective Functions

No.	Organization	Functions
1.	MIME	Overall supervision, establishing technical standards, and monitoring of electrification projects countrywide
2.	Provincial governments/MOI	Registration of CEC
3.	EAC	Technical review of generation and distribution facilities of mini-grids. Review of tariff structure and level. Issue of REE license[19]. Assessment of account reports to be submitted once a year. Account auditing when required assessing the financial situation of CEC as an REE. Re-examination of licensing conditions at the time of license update every 1 to 5 years.
4.	DIME	Initial enlightenment and supply of information to villagers. Periodical inspection after completion, technical guidance, auditing on behalf of CFR, collection of BCS lease charges from CEC and remit to CFR.
5.	REF/CFR	Financial support (subsidy and loan) to rural electrification projects by CEC/REE. Financial support to NGO for its supporting activities to CEC through the bank account of CEC. Capacity building of DIME, NGO, etc.
6.	NGO/consultants[20]	Supporting services in setting up and management of CEC and technical matters on contract basis with CEC[21]
7.	Suppliers etc.	Supply of equipment, repair of equipment on a fee basis after expiry of the guarantee period

Source: JICA study team

[18] 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.

[19] As per Electricity Law, EAC can only issue a license to a company or, for a small operation, to an individual. Solutions are either (1) the CEC has to authorize one representative to take the responsibitlity of a licensee or (2) the CEC can be registered as a company.

[20] MIME is examining mobilization of private companies such as ESA(Energy Service Agent), ESCO (Energy Service Company), etc.

[21] In a few years, there would be an option of horizontal support by existing CECs like Anlong Tamei.

(6) Rural Electrification Program

The following are the basic policies of the MP for planning rural electrification:

1) Adoption of Three Levels of Electrification

Taking into account the high penetration level of battery lighting and the fact that nearly 20% of the people of Cambodia are living in those areas (outside the PAGE) that have very low probability of grid extension by the year 2020, the three level electrification has been adopted as shown in Table 2.2.3[22].

Table 2.2.3 Three Levels of Electrification

Region			Electrification Plan				
			Level	Consumption Standards		Type	Energy Sources
				Watt	kWh/month		
Nationwide	Inside PAGE	On-grid	3	<400	50	Grid	National grid
	Inside PAGE	Off-grid	2	100 (30-200 subject to village economic levels)	10	Decentralized mini-grid	Micro hydro, 24 hours operation possible
	Outside PAGE						Biomass gasification power, hourly supply depending on demand
							Diesel power, hourly supply depending on demand
			1	10 (40 for households with TV)	3	BCS, SHS for public facilities	Existing diesel power, Solar power

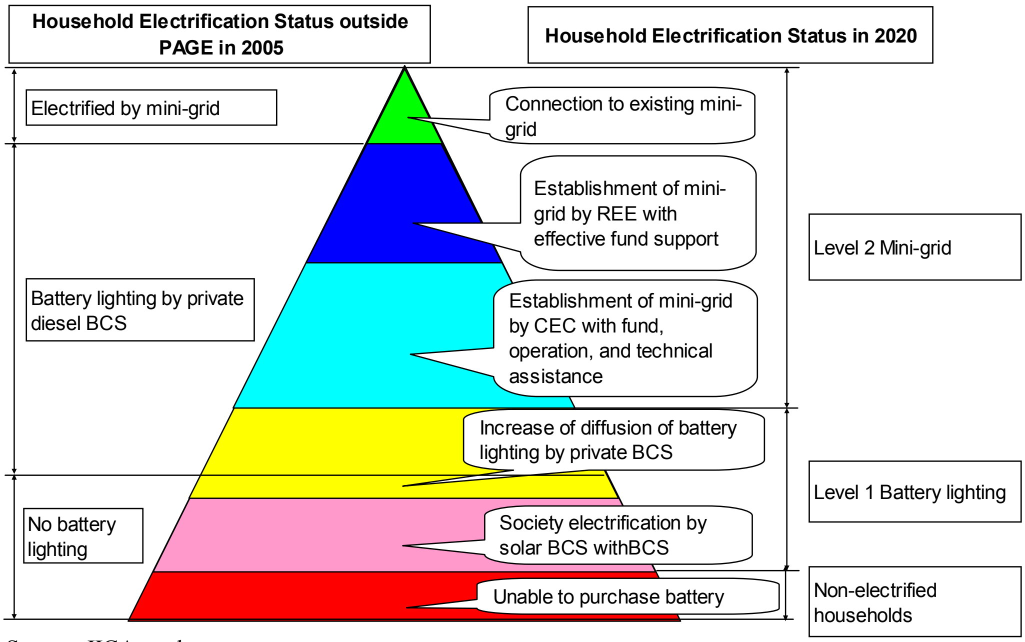
Source: JICA study team

Figure 2.2.9 illustrates applications of the three levels of electrification to non-electrified areas depending on the household income level as of 2005[23]. Figure 2.2.9 represents the area outside the PAGE, which covers main parts of the off-grid areas. The current status of the community electrification is shown on the left side, type of electrification in 2020 in the center triangle, and its electrification level on the right. For those villages in the bottom layer[24], battery lighting with a solar BCS at Level 1 will be promoted. The BCS will be a principal driving vehicle for achieving the 100% level of village electrification.

22 In the table, diesel generator is also included as a candidate energy source. In the suburbs of urban cities and plain areas along the Mekong River, there are those villages that have little potential of micro hydro and lack of shrub-lands for biomass plantation. If electricity supply is required only for 3 hours or less per day, a diesel generator will be a cheaper solution than the other renewable energy sources. For such cases, a diesel generator is also provided as a candidate option for energy sources.

23 The area of each layer does not represent actual share ratio.

24 As shown in the location map at the beginning of this report, these villages are concentrated in the northern and north-eastern provinces. This distribution matches with the distribution of low literacy villages. It is considered that the village income level is affected by their geographical location.



Source: JICA study team

Figure 2.2.9 Present and Planned Levels and Types of Electrification Outside PAGE

2) Maximum Use of Renewable Energy

In accordance with the basic approach of the MP, the renewable energy potential, biomass gasification power which is a new technology to Cambodia, power sources of mini-grids, and power sources for BCSs are explained below in brief:

a) Renewable Energy Potential

The potential of renewable energy in the off-grid areas and its characteristics are presented in Table 2.2.4 and Figures 2.2.10 to 2.2.12[25]. Figure 2.2.10 shows the monthly variation of solar irradiation obtained from the satellite data[26]. Black marks in Figure 2.2.11 show potential sites for micro-hydro and red lines environmental protection areas. Figure 2.2.12 indicates that most of the villages, except in the pink colored areas, have grass land and shrub land that alone can grow sufficient biomass for electrification[27].

25 It does not include such micro hydro or wind power potentials that would connect to the grid and feed its excess energy accordingly. Detailed information on this potential is presented in Attachment-10.

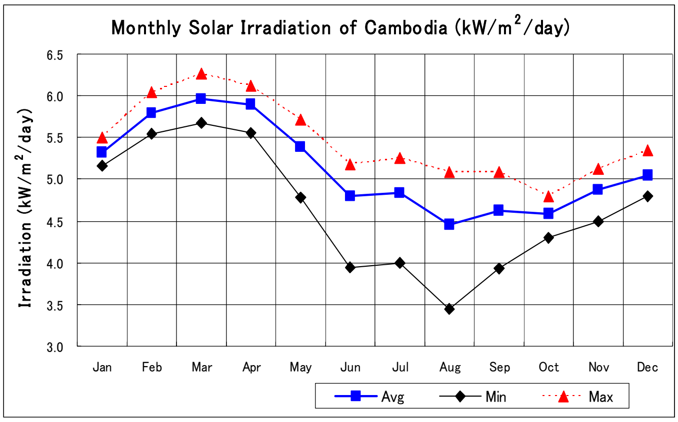
26 It has been clarified through calibration of the satellite data with ground observation data that planning based on the minimum monthly values will be on the conservative side.

27 The forest cover areas in the north-eastern part etc. are also pink-colored in Figure 2.2.12. These are the results of GIS processing where for convenience as to treat those areas not inhabited are treated as not suitable for biomass power.

Table 2.2.4 Renewable Energy Potential as Power Sources for Rural Electrification

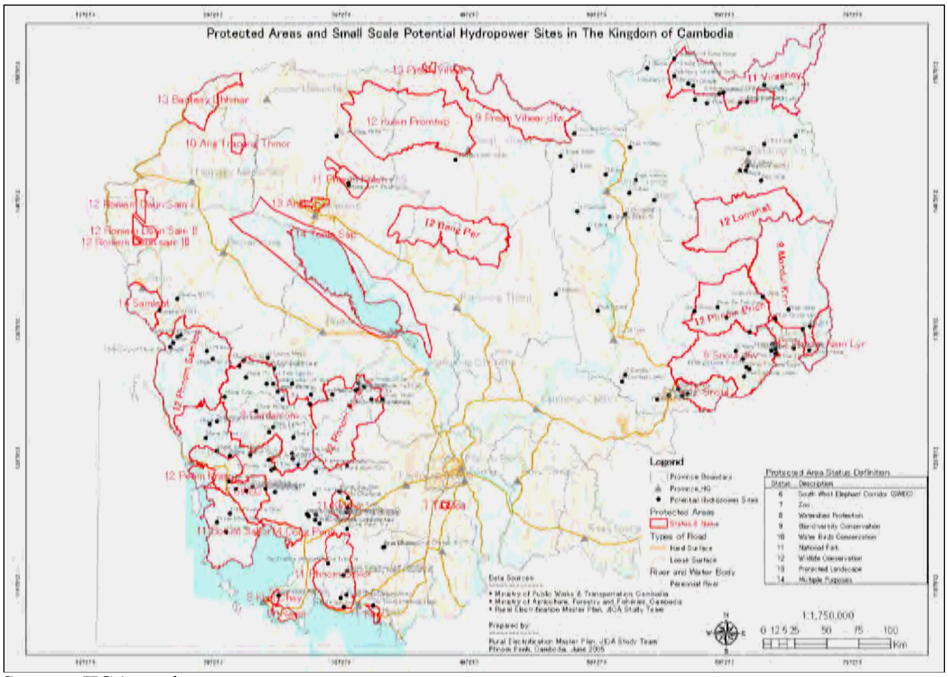
No.	Energy Source (Type)	Characteristics of Potential
1.	**Micro-hydro power** (mini-grid)	Micro-hydro power (MHP) potential is limited to mountainous or hilly areas mainly in the eastern and south-western part of the country. In the plain areas, which cover more than half of the country, there is hardly any potential for MHP.
2.	**Biomass** (mini-grid)	Blessed with abundant solar irradiation, precipitation, and land resources, biomass resources are abundant all over the country, and there is high biomass farming potential as well (even grassland and shrub land alone are more than sufficient to grow the required fuel trees).
3.	**Solar** (BCS, SHS)	Abundant all over the country (annual average of monthly minimum is 4.7 kWh/m^2/day)
4.	**Wind** (BCS, SHS)	Scarce. Average wind speed at 20 m above ground level is as low as 2.6 m/s. Wind power may be used for BCS in wind corridors.

Source: JICA study team



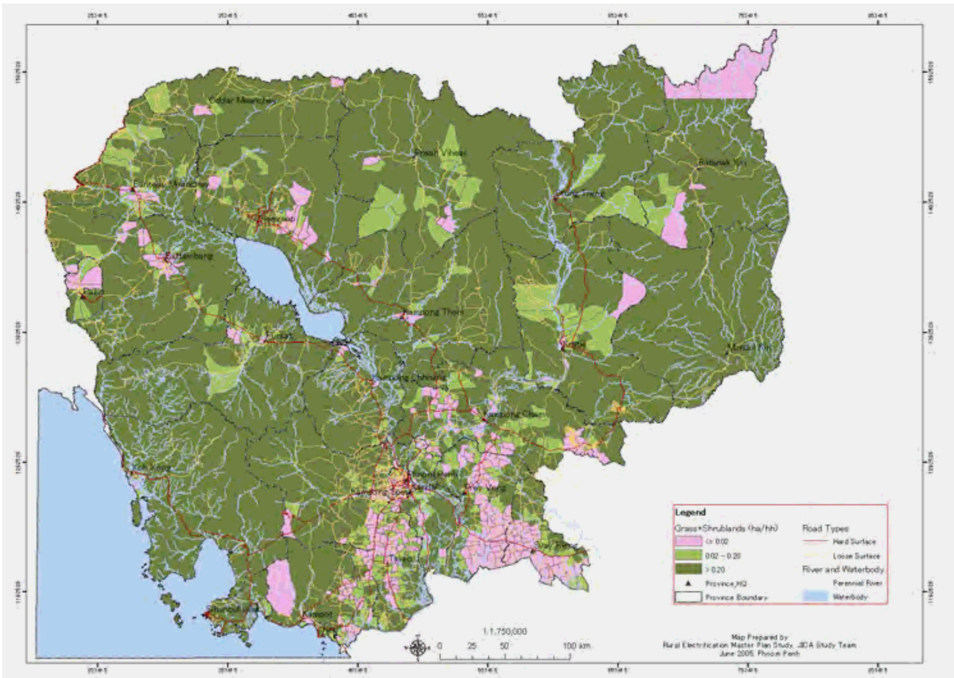
Source: Processed by JICA study team from NASA satellite data

Figure 2.2.10 Monthly Variation of Solar Irradiation in Cambodia



Source: JICA study team

Figure 2.2.11 Micro-hydro Potential and Environment Protected Areas



Source: JICA study team

Figure 2.2.12 Per Household Area of Grassland and Shrub Land

b) Biomass Gasification Power

The biomass gasification power has the following advantages in application to decentralized mini-grids for rural electrification:

1	It can be applied to most of the villages in Cambodia since these have grass land and shrub land in sufficient areas to grow fuel trees without affecting agricultural production;
2	Fuel trees can be grown locally within the community and, therefore, the supply can be stable and sustainable if combined with an energy reserve of trees to cope with droughts, fire in plantations, flooding, and so forth;
3	Some fast growing tree species can be harvested from one year after planting and every 4-6 months thereafter like mulberry trees for silk production;
4	Unit fuel cost is \$0.03/kWh, being much lower than diesel fuel cost at \$0.23 /kWh;
5	The money paid for fuel trees will remain inside the community and can be reused for other economic activities;
6	Poor households, if given priority in farming fuel trees, can also join CEC and receive electricity by paying tariff out of the tree sales;
7	Some types of gasifier require less maintenance work than diesel engines;
8	Generating capacity can be extended when demand has grown beyond the planned level.

Biomass gasification power does not have a long history of applications over 100 years like micro-hydro. However, some types of small scale gasifier (down draft type with closed top and side air nozzles using charcoal) had over one million applications to vehicles during the World War II. Such small scale gasifiers up to 100 kW are suitable for rural electrification. In India, China, and Myanmar, biomass gasification power is applied as a source of power for rural electrification, irrigation pumps, and rice mills[28].

In Cambodia, one small scale gasifier[29] was introduced in 2004 for research purposes. Another was installed in January 2005 for electrification of Anlong Ta Mei village in Battambang Province and has been operated since then (refer to photographs of Figure 2.2.13).

Source: Courtesy of CEC Anlong Ta Mei and SMEC, photographs by the JICA study team

Figure 2.2.13 Existing Rural Electrification by Biomass Power[30]

[28] Small scale gasifiers have spread on a commercial basis but with very high subsidy in India (total capacity amounted to 55,000 kWe), in China (mainly used for thermal applications), in Myanmar (135 sets in total only since 2000, and of these 25 sets are for power generation). For details, refer to Vol-4 pre-feasibility study, Appendix-1.

[29] Continuous rated output is 7 kWe.

As for biomass gasification power (BGP), the numbers of past installations and manufactures on a commercial basis are still limited compared to micro hydro and diesel generators. On the other hand, BGP has such advantages as: it is applicable to almost anywhere in Cambodia, fuel cost is as cheap as one seventh (1/7) that of diesel oil, fuel can be self-supplied in the community and is not affected by the international supply-demand balance, money paid for fuel purchase will remain within the community and can be utilized for other economic activities, and it has job creation effects for harvesting, transportation, and chopping to a suitable size for gasifiers (refer to Figure 2.2.14). Biomass use is recognized to create job opportunities even in Europe and the US. Such an effect is expected in the rural area of Cambodia in particular.

Source: CEC Anlong Ta Mei, phtograph by JICA study team

Figure 2.2.14 Fuel Wood Prepared for Gasifier

However, commercial technology available as of 2005 may have an issue in final disposal of wastewater from gasifiers. The study team is of the view that after confirmation, through pilot projects, of 1) solutions to such technical issues and 2) feasibility of management of the electricity business by CEC and fuel tree growing and supply by contracted farmers, BGP should be applicable to rural electrification also in Cambodia.

The significance of biomass energy and the need for setting up a policy framework by the government were confirmed in the third sub-group meeting at the "Energy Sector Strategy Workshop of Cambodia" held on October 27, 2005, hosted by the World Bank[31].

BGP technology is hardly known in Cambodia. Through the MP, MIME has recognized the important role of BGP in the rural electrification in Cambodia, and plans to implement two pilot projects for public relations and verification of its applicability in Cambodia. Of these pilot projects, one would be of a small scale, around 10 kWe, that can provide electricity for about 100 households. The other is for electrification of a government facility. Apart from these, an NGO (SMEC) also has two plans. One is a new electrification project and the other is expansion of an existing project.

c) Power Sources of Mini-grids

As shown in Table 2.2.5, BGP satisfies the required conditions as an energy source for mini-grids except for the arrangement of initial capital costs. In addition, if the plant factor (usage ratio) of power generation equipment is higher than 12%, the unit cost of electricity will be lower than that from a diesel generator (Figure 2.2.18). The study team considers it is appropriate to apply three types of renewable energy (micro-hydro, biomass gasification power and diesel power) as sources for decentralized mini-grids in Cambodia.

30 Left hand side is gasifier, right hand side is fuel wood plantation.

31 In that group meeting, one person from MIME, 3 from the World Bank, 2 from the JICA study team, and 6 from NGOs participated. See Proceedings, Cambodia Energy Sector Strategy Reviews Workshop, October 27, 2005, Phnom Penh, Cambodia.

34 There are risks of escalation in the fuel price and fuel supply shortages due to road blockage during the rainy season.

Table 2.2.5 Required Conditions as Energy Sources for Decentralized Mini-grids

No.	Item	Diesel	MHP	Solar	Biomass
1.	Operation and maintenance works can be undertaken by trained villagers who have maintenance experience of diesel engines.	P	P	P	P
2.	Fuel is not required or sustainable purchase and procurement are possible.	PWC[34]	P	P	P (Fuel wood farming)
3.	Investment cost can be recovered within the range of ability-to-pay ($3 to 5 per month) (Prerequisite conditions for investment)	P (Loan)	PWC (High ratio subsidy and soft loan)	PWC (100% subsidy for equipment)	PWC (Soft loan)
4.	Power generation at required scale (10-200 kWe) as a decentralized independent power system is possible.	P	P	D[35]	P
5.	Unit generation cost [36] ($/kWh)				
	Plant factor: 15%	0.59	0.85[37]	-	0.56
	Plant factor: 30%	0.40	0.40	-	0.28

Note: P: Possible , PWC: Possible with condition, D: Difficult
Source: JICA study team

d) Power Sources for BCS

Candidate power sources for BCS in the plain regions are biomass[38] and solar in terms of renewable energy potential[39]. As BCSs are for rural villages where there is little penetration of battery lighting[40], the key factor is easiness of operation and maintenance. Solar power does not require any generator (panel) operation, and is almost maintenance free[41]. On the other hand, biomass power generation is difficult to apply to remote small villages in view of the required output scale for a BCS at 1 to 4 kW being too small to apply a biomass gasifier. Operation and maintenance of the machine is also required. In specific wind corridors, wind power can also be a power source candidate for a BCS. In the case of applying wind power for a BCS, observation of wind conditions throughout the year is required, and special attention should be paid to the maintenance system for mechanical parts.

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35 Technically possible, but economically unrealistic.

36 Including tax, at the consumer end.

37 There are projects also of high economic efficiency with unit electricity costs of the order of $0.30/kWh that utilizes waterfalls.

38 When a village in mountainous or hilly areas has micro-hydro potential, it would be better to plan for direct electrification with wires including pico-hydro, rather than for battery lighting powered by micro-hydro.

39 In the location map at the beginning of this report, villages with red dots were selected as candidates for Level 1 – battery lighting (solar BCS). Solar BCS is applicable to any area. In selecting candidate villages, judging criteria were employed considering the probability of grid extension, existence of REE mini-grids, electrification level, and penetration level of battery lighting (as an indirect index for ability-to-pay). Solar BCS will be used mainly for battery lighting. In the MP, it was planned to install solar BCS as *Social Electrification* to those villages where even battery lighting is not accessible. Those villages having a TV penetration level higher than 10% were judged to have the necessary ability-to-pay and were planned as candidates of mini-grids.

40 Those red points shown in the location map at the beginning of this report have been identified through the Study as candidates of battery lighting (Level 1 solar BCS). Solar BCS can be applied to anywhere in the off-grid areas. These candidate villages were selected with criteria based on probability of grid extension, existence of mini-grids, level of electrification, penetration level of TV (a substitute of battery diffusion level and used as an indirect parameter to measure ability-to-pay). Main objective of solar BCS is to charge batteries for home lighting. It has been planned in the MP as *Social Electrification* to install solar BCS to such villages where people have no access even to battery lighting.

41 After target village is electrified with mini-grid or the grid electrification, BCS equipment leased from CFR will be returned to CFR and can be shifted to the other non-electrified villages. Therefore, the ownership of BCS equipment should remain with the government (REF/CFR) and equipment will be leased to CEC on nominal charge basis.

Diesel power generation, though it is not renewable energy, can be employed also for the small scale demand of a BCS. A diesel generator can be purchased in local markets and sales routes for fuel have been established, except for very remote areas. Because of its high technical reliability and low prices, all the existing BCS operators are using diesel generators. However, in small scale rural villages, there are several issues such as recruitment of operation and maintenance staff, transportation of fuel over roads that are in a bad condition, in the rainy season in particular, risks of fuel price fluctuation, and low profitability inherent in small scale BCS business . In this connection, the study team is of the opinion that diesel BCS operation should be left in the hands of markets, waiting for participation from the private sector where profitable.

3) Framework of Rural Electrification Program

Targeting about 14,000 villages in the whole of Cambodia, a rural electrification plan has been formulated using a GIS database. The plan consists of grid extension by EdC, decentralized mini-grids powered by micro-hydro, biomass, and diesel, and solar home systems (SHS) and solar battery charging systems (BCSs). The plan is shown in the location map at the beginning of this report and is featured in Table 2.2.6.

Table 2.2.6 Framework of Rural Electrification Program

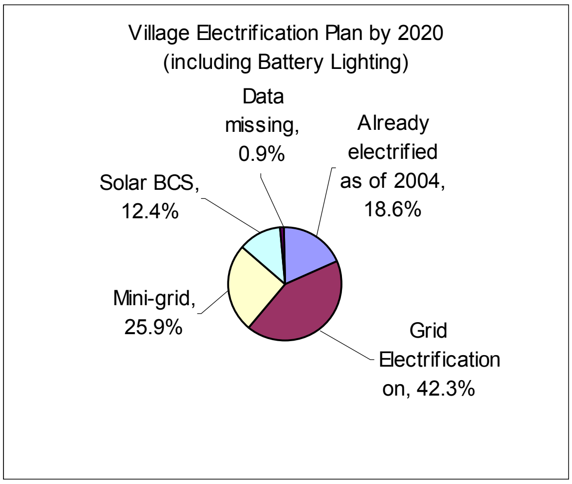
Name of Representative Regions	Energy Sources	Number of Villages	Number of Households[44]	Target Number of Households for Electrification by the Year 2020
Electrified area (2004) **A**	Grid/Diesel	**2,588**	**623,523**	**350,000**
Newly electrifying areas				
Grid extension[45] **B**	Grid	5,885	1,007,291	600,000
Off-grid Area (2020)				
Northeast, Southwest and mountainous areas	Micro-hydro, hybrid	137	18,541	9,000 (50% of left)
Tonle Sap coastal region, etc.	Biomass gasification	3,071	501,636	168,000 (33% of left)
	Diesel	392	69,390	23,000 (33% of left)
Sub-total of mini-grids C		**3,600**	**589,567**	**200,000**
Northeast or North provinces	Solar BCS SHS **D**	1,720	237,570	60,000 12,000
Sub-total of newly electrifying areas E = B+C+D		**11,205**	**1,834,428**	**872,000**
Total A＋E		13,914[46]	2,457,951	1,222,000

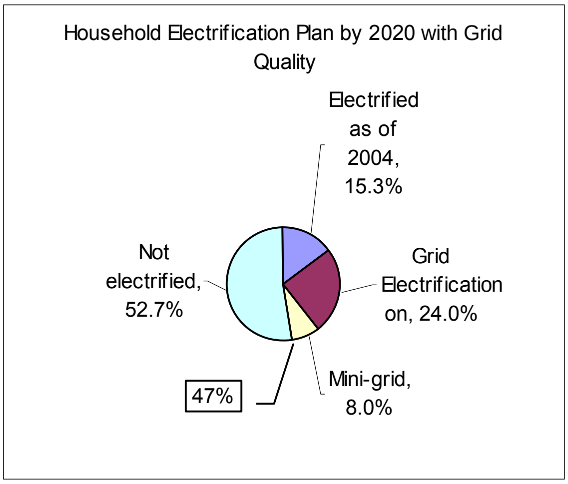
Note: Inside bold lines is for the off-grid area. In this MP, as potential for local wind corridors cannot be obtained, such potential is not included in this electrification plan.
Source: JICA study team

As shown on the left side of Figure 2.2.15, 100% (13,793) villages will be electrified including solar BCS and SHS by the year 2020 . Shown on the right side are household electrification levels by the

44 This shows a total household number in the villages, not the number of electrified households.
45 Including those villages identified as candidates for the grid electrification as the first option, biomass and diesel mini-grids as the second option.
46 Including 121 villages with village data not available.

year 2020: 24% will be newly electrified by grid extension, and 8% by mini-grids, to achieve the intermediate target of household electrification set at 47%.



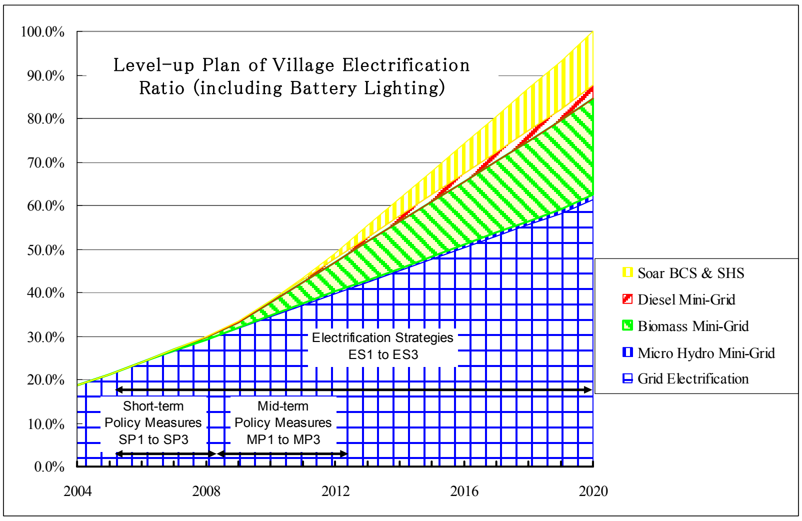


Source: JICA study team

Figure 2.2.15 Constitution of Village and Household Electrification Plans by 2020

Figure 2.2.16 shows an improvement plan of the village electrification level and Figure 2.2.17 for household electrification level. From the both figures, it may be read that the principal part of the electrification should be undertaken by grid electrification. However, in achieving the village electrification target of 100%, the mini-grids and solar BCSs will have a significant share of about 38% in total.

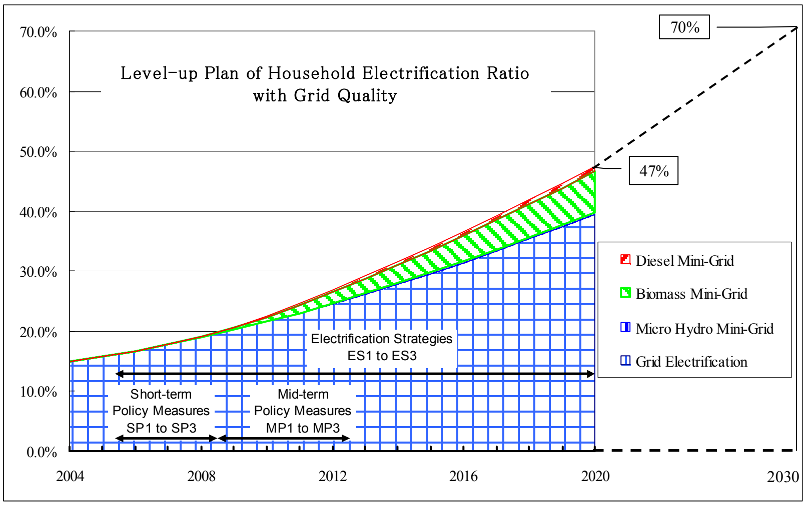
The contribution of the mini-grids to household electrification may seem small in Figure 2.2.17 at a glance. However, the household number outside the PAGE is less than 20% of the national total and the mini-grids will electrify about 34%[49] of the households in the off-grid areas. Therefore, the impact of mini-grids on the off-grid areas will be significant.



Source: JICA study team

Figure 2.2.16 Improvement in Village Electrification Level (including battery lighting)

49 From the total number of household for mini-grid in Table 2.2.6, 200,000/589,567 = 34%.



Source: JICA study team

Figure 2.2.17 Improvement in Household Electrification Level (excluding battery lighting)

To achieve the electrification targets, the 16 year period from 2005 to 2020 is divided into the following four phases. MIME should monitor the progress of each electrification phase and review and update the MP[50]:

Electrification Phase 1	2005-2008
Electrification Phase 2	2009-2012
Electrification Phase 3	2013-2016
Electrification Phase 4	2017-2020

(7) Financial Requirements

As shown in Table 2.2.7, a total investment cost of about $427 million is required to implement the MP in the whole rural electrification sector for the 15 year period from 2006 to 2020. Of this, the grid extension requires $280 million. The target off-grid areas of the MP require about $147 million (about $10 million per annum on average). In the off-grid areas, financing requirements are $11 million for micro-hydro mini-grids ($1,229 per household), $100 million for biomass mini-grids ($592 per household), and $10 million for diesel mini-grids ($424 per household).

Grant installation of solar BCS requires about $21 million ($351 per household). REF has a source of subsidy for 12,000 sets of SHS[51]

50 A new plan of grid extension including 22 kV distribution lines will be prepared every 4 years since such planning, financial arrangement and implementation will require about 4 years in total. Therefore, the plan of the off-grid electrification should better be reviewed every 4 year based on the grid extension plan. The off-grid electrification plan should also be monitored on its progress and be updated. In this regard, the off-grid plan should be updated every 4 years following the grid plan updating.

51 It is a prerequisite for penetration of SHS that a 75% of the capital costs should be raised as equity capital by beneficiary households or supplier's credit.

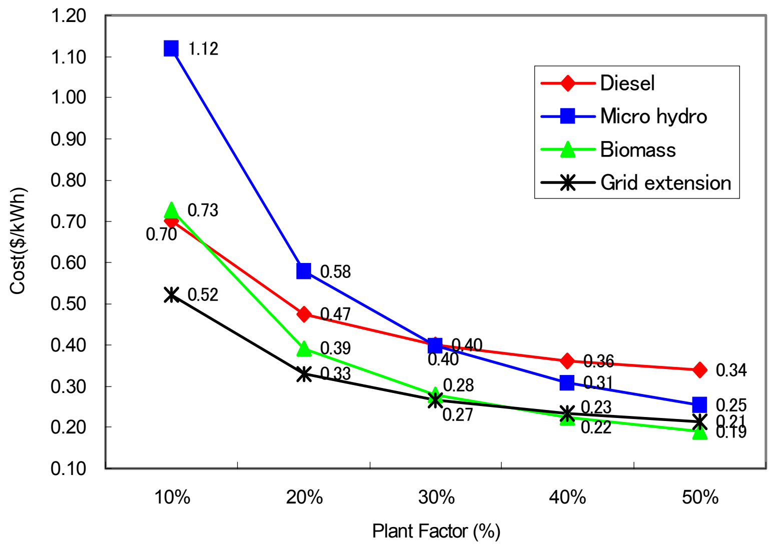
Table 2.2.7 Rural Electrification Plan and Financing Requirements

Type of Electrification	No. of Candidate Villages	No. of h.h. to be electrified by year 2020	Total Cost	Total Cost per h.h.	Fund Source of Capital Costs		
			($1,000)	($/h.h.)	Subsidy	Equity	Loan
Electrified as of 2005	2,062	(350,345)	-	-	-	-	-
Newly Electrified by Grid	6,411	**600,000**	**280,140**	467	70,035	42,021	168,084
MHP/Hybrid	137	9,000	11,064	1,229	5,532	1,106	4,426
Biomass	3,071	168,000	99,498	592	24,875	14,925	59,699
Diesel	392	23,000	9,760	424	2,440	2,440	4,880
Sub-total of Mini-grid	**3,600**	**200,000**	**120,322**	**602**	**32,847**	**18,471**	**69,004**
Solar BCS	1,720	60,000	21,045	351	19,993	1,052	0
SHS(World Bank)		12,000	5,520	460	1,380	1,380	2,760
Sub-total of off-grid area	5,320	**272,000**	**146,887**	540	54,219	20,903	71,764
Village data unknown	121	-	-	-	-	-	-
Total	13,914	**872,000**	**427,027**	490	124,254	62,924	239,848

Source: JICA study team

(8) Ability to Pay and Unit Costs of Electricity

As of 2005, battery users are spending more than $3 per month, including purchase costs of their battery[52]. Therefore, battery-using households are considered to have an ability-to-pay for mini-grids with its tariff level at $3 to $5 per month[53]. Figure 2.2.18 shows unit costs of electricity at the consumer's end with its plant factor as abscissa (X axis). The estimates of the study team show that "grid electrification" is the cheapest alternative when the plant factor is lower than 40%. At a plant factor of 30%, biomass is the second cheapest and micro-hydro the third. Diesel generation becomes the second cheapest when the plant factor is lower than 10%.



Source: JICA study team

Figure 2.2.18 Plant Factors and Unit Costs of Electricity at the Consumer End

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52 Even with the minimum use of a battery, only for home lighting, people spend about $2 per month as battery purchase cost (12V-50Ah battery at about $25 and used for 1 to 2 years), and $1 - $1.50 for battery charging and expenses for oil lamps for supplementary lighting. The total expenditure for lighting will be about $3 per month.

53 If poor households limit use of electricity to only one light, their monthly tariff will be about $0.50, which is much cheaper and better in quality than battery lighting. Barriers to implementing mini-grids are in raising the initial capital costs.

56 "Action Plan for the Promotion of Rural Electrification" and "Supporting System for Promotion of Rural Electrification", which are proposed by the study team, is presented in Attachments-7 and 8.

(9) Environmental and Social Considerations

According to the Cambodian standard for Environmental Impact Assessment (EIA), an EIA is required for micro-hydro when its installed capacity exceeds 1 MW and for thermal power (diesel, biomass) when it exceeds 5 MW. The scale of micro-hydro and biomass power required and recommended in the MP are smaller than 1 MW, and thus EIA is not required.

In Cambodia, environment-protected areas are defined as shown in Figure 2.2.11. Those micro-hydro mini-grid schemes situated inside the protected areas (Bu Sra Scheme, etc.) require environmental screening. In addition, according to the environmental and social consideration guidelines of JICA, those areas where minority people live keeping their traditional way of life, are categorized as "Sensitive Areas". Bu Sra Commune in Mondul Kiri Province is a village where most of the population belong to a minority group. Special consideration should be given to their way of living when formulating such development plans.

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

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

2.2.2 Short-term Policy Measures for Promotion of Rural Electrification

To cope with the issues of implementation of the MP, it is recommended that MEF and MIME implement the following short-term policy measures in addition to early commencement of REF operation:[56]

SP1 Financial Arrangements

SP1-1 Creation of Tax Exemption System for Imports of Renewable Energy Equipment

With limited financing resources available for subsidies to CECs/REEs, it is quite important for RGC, so as not to be depending on grants from donor agencies, to make every effort to arrange its own sources within Cambodia for such subsidies. The JICA study team recommends that MEF and MIME examine and create an exemption system from import customs and value added tax (VAT) on renewable energy equipment[57]. The rationale of the exemption is as follows:

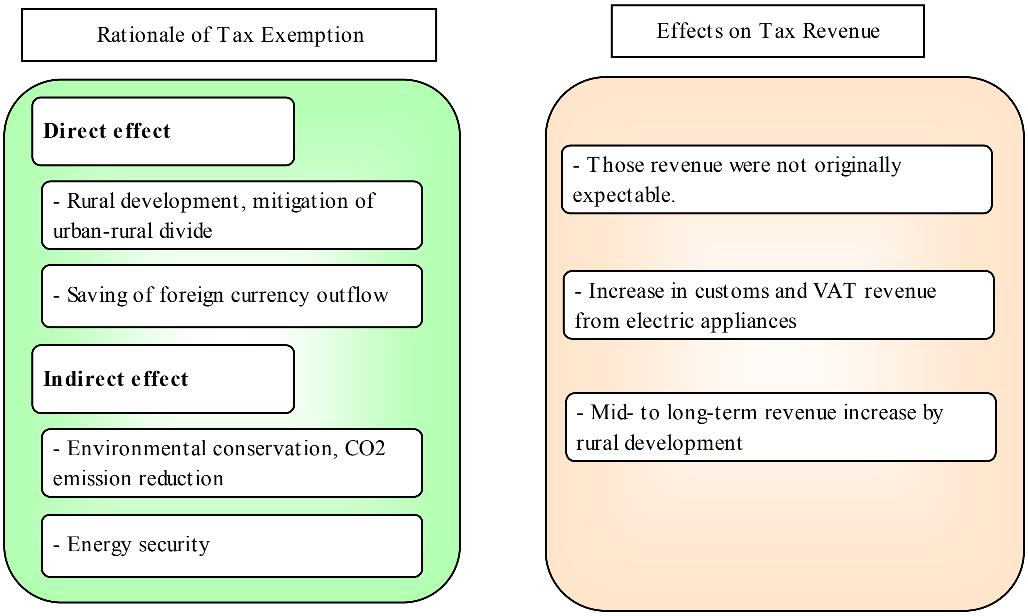
Renewable energy equipment is not currently manufactured in Cambodia and its import is therefore required to implement the MP. Most of the imported renewable energy equipment is subject to 15% of customs tax and 10% of VAT. If the proposed tax exemption system is implemented, a solar BCS can gain an effective support of nearly 25% of the total cost. In the case of biomass power, though domestic components for procurement of materials and construction work share a significant part of the costs, the support effect would amount to nearly 10% of the total cost.

The rationale of tax exemption for RGC and its influence on tax revenue are illustrated in Figure 2.2.19 and are: 1) promotion of environment-friendly renewable energy applications, and 2) reduction in the urban-rural divide through rural electrification and rural development. In other words, RGC can

[57] According to MEF, the taxation principle of customs and VAT should be firmly maintained. However, for financial assistance projects from international agencies, RGC normally prepares counterpart funds of up to 20% of project cost, that can be allocated for payment of taxes.

[59] There is an example of a mini-grid with biomass gasification power in Anlong Tamei village in Battambang Province. In three months after the start of operation in February 2005, the television penetration increased to 95% of the total households.

save costs in advance that would be incurred for future environment-protection or future rural development, by promoting rural electrification now with renewable energy, and 3) several advantages can be expected by developing domestic energy sources, such as contribution to the energy security of Cambodia and saving foreign currency that would be spent on fuel imports.



Source: JICA Study Team

Figure 2.2.19 Rationale of Tax Exemption and Effects to Tax Revenue

Next, in terms of the tax revenue, 1) without promotion of the rural electrification with renewable energy, renewable energy equipment would not be imported on a significant scale. Therefore, customs revenue on such equipment would not be expected. The proposed exemption does not mean a simple decrease in the revenue, 2) by promoting rural electrification, import of home electrical appliances will increase to contribute to customs and VAT revenue,[59] and 3) with the effects on rural development, industrial development and increase in the household incomes, a mid to long-term increase in the tax revenue is expected.

SP1-2 Creation of Cross Subsidy System

In and after 2008, electricity imports from Viet Nam, Thailand and Laos will start and the present grid electricity tariff can be reviewed and lowered. At that stage, it is recommended that a cross subsidy system (at 1.5 to 2.0% of the revised electricity tariff[61]) be established as a redistribution of the ODA benefits from urban to rural areas within Cambodia. The urban residents are enjoying low tariff electricity (at about 15 cents per kWh on average) owing to the foreign economic assistance provided for generation and transmission projects in the past[62]. According to an estimate by the study team, it would amount to about $2 million per annum. As the grid electrification progresses, the amount of cross-subsidy would also increase. The cross subsidy from the grid users can be collected by adding it on top of the tariff of EdC (as a tariff surcharge) and it can be transferred by EdC every month to a proposed CFR[63]. Such a system appears workable. Without making new flows of money transactions, such a system could go smoothly.

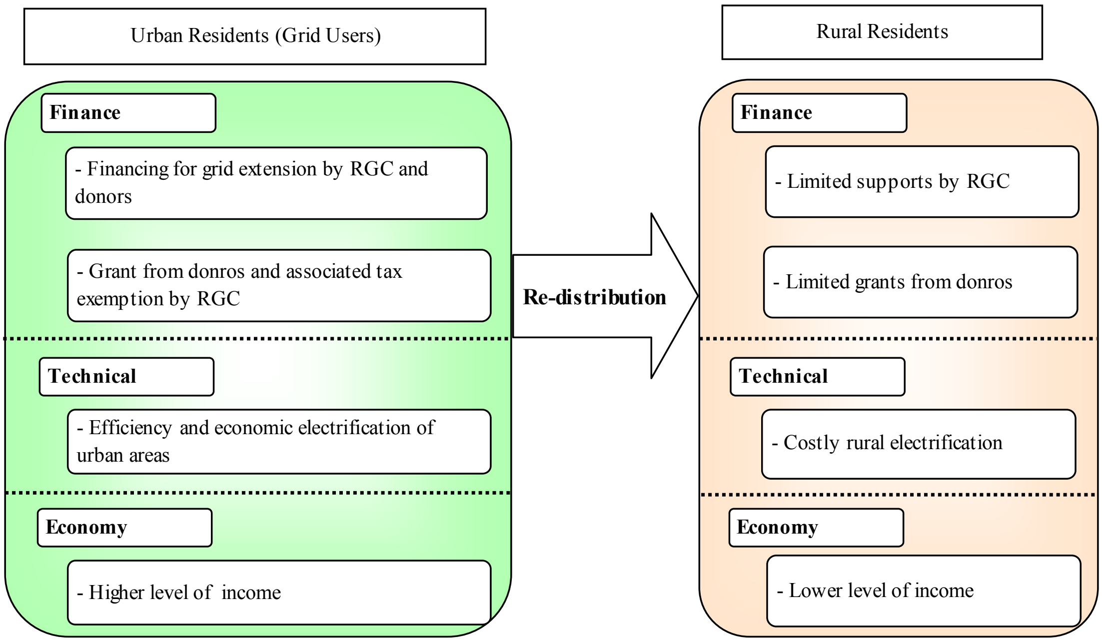
According to interviews with MEF officials, MEF puts priority on foreign currency introduction to the industry sector to promote the economic growth of the country. For this, MEF regards it as important

[61] For the cross-subsidy system and its scale of operation, discussion among the government organisations (MEF, MIME, EAC, EdC) is essential. Currently, EdC users in urban areas are benefiting from a cross-subsidy system.

[62] Beneficiaries from grant projects are also required to raise the same contribution. The study team recommends that such contributions be allocated to DIME, which is in charge of implementation of grant projects, for their activities in supporting CECs.

[63] EdC collects electricity tariffs from private and corporate customers supplied from the grids and wholesale revenue from REEs. By adding 1.5% as a tariff surcharge to the tariff of EdC, cross subsidy can be collected from all the grid customers.

to lower electricity prices which are extremely high compared with neighbouring countries. Therefore, MEF is rather against such a tariff surcharge, even if small. On the other hand, EdC's revenue share of the industry sector stays at 12%. The largest demand on EdC is from residential and commercial users. Even if excluding the industry sector users from the surcharge system, such an effect can be regarded as small against the total required amount for cross-subsidy. To achieve a perfect balance between "Industrial Development" and "Rural Development" which are both national policies of Cambodia, it is supposed to be realisiic to charge EdC users (except industry sector users) and REE users connected to EdC grids through REE mini-grids as resources for cross-subsidy. In reality urban users (who are current beneficiaries) will become capital contributors as well.



Source: JICA Study Team

Figure 2.2.20 Backgrounds to Need of Cross Subsidy

As shown in Figure 2.2.20, the urban residents are blessed in various aspects of electricity supply. To the contrary, the rural residents have handicaps. The study team considers that such benefits originating from foreign economic cooperation be redistributed from the urban to the rural people who have no electricity, to achieve Social Equity. Rural electrification projects involve a heavy burden of fixed costs and it becomes costly because of limited use of power generation and distribution facilities for only several hours a day during the night time. In addition, financial assistance from RGC and international donor agencies can hardly reach the sparsely populated rural areas. Furthermore, the household income level is low in general compared to the urban. On the other hand, urban residents are blessed with benefit (tariff of less than 15 cents) from the advantages of the scale of the National Grid and financial support from international funding agencies. Beneficiaries from electrification projects constructed with grants are the same.

In addition to the rationale from the viewpoint of *Social Equity*, such a supporting system from "beneficiaries" to "non beneficiaries" could have the understanding of the urban residents, though sufficient explanation is essential. It is proposed that MIME should talk with MEF and EAC for establishment of such a cross subsidy system, to enable enactment of the system by 2007 and to put it into operation from 2009 at the latest.

SP2 Preparation for Establishing Complementary Functions to REF (CFR)

SP2-1 Improvement of Access to Soft Loans

REF is under preparation for operation as of December 2005. The functions of REF are limited to 25% subsidy and technical assistance. In addition, REF supports those grid extensions for more than 300 households, SHSs, micro-hydro and diesel power. The study team propose that after implementation of these projects, the present supporting scope of REF be expanded to include small scale communities, solar BCSs, and biomass power[67].

The study team recommends that a Complementary Functions to REF (CFR) be established in MEF-MIME. The principal functions of CFR should include provision of soft loans and technical assistance on biomass related technology and community management in particular. The proposed features and functions of CFR are outlined below in comparison with REF:

Table 2.2.8 Functions of Existing REF and Proposed CFR

Items	REF	CFR
Target body	REE	CEC and REE
Types of electrification supported	Grid extension	Mini-grids by biomass power
	Mini-grids by micro hydro	Solar BCS
	Mini-grids by diesel power	Others
	SHS	
Extension of supports (proposal of study team)	Mini-grids by biomass power	
	Solar BCS	
Contents of supports	25% subsidy to REE	CEC: 60% loan plus 25% subsidy
		REE: 50% loan plus 25% subsidy
	TA to REE	TA to CEC and on biomass technology through DIME and NGO
Notes:	Projects with beneficiaries greater than 300 households will be supported.	No specific limit in community size except mini-grids by biomass power that should preferably have a size greater than 200 households.

SP2-2 Establishment of Supporting System to CEC

The study team recommends that the required functions and conditions for Complementary Functions to REF (CFR) be examined and clearly defined by MEF-MIME. CFR should be established before 2008 in order to provide its services in full swing from 2009 or even earlier. The study team proposes that CFR complement the grant function of REF and provide the following functions:

67 A median of village household size in Cambodia is 140. As the village size in the off-grid areas tends to be smaller, it is necessary to remove the limitation of village size, for a solar BCS in particular. In addition, a solar BCS is a main driving vehicle for improving the village electrification target while biomass power is a main energy source for mini-grids in the off-grid areas. Thus it is necessary to include these in the scope of supporting electrification types.

69 As for prioritization among the electrification plans and selection criteria of Pre-FS candidates, refer to Part 3, Section 3.3.

1) Provision of long-term loans with low interest rates;

2) Capacity building and support to MEF and agency banks;

3) Reinforcement of organization and human resources development, technical and financial support to external facilitators (DIME, NGOs, consultants, etc.) who support and give guidance to CECs/REEs; and

4) Introduction, development assistance and enlightenment of electrification technology by renewable energy.

A draft idea of CFR terms of reference by the JICA study team is detailed in Attachment-10.

SP3 Implementation of Pilot Projects (micro-hydro, biomass, solar BCS)

The JICA study team recommends that pilot projects[69] be implemented with two micro-hydro mini-grids[70], four biomass mini-grids[71], and one solar BCS. For these candidates, a pre-feasibility study has been conducted as part of the Study. These pilot projects are to be operated by CECs to prove the adequacy of operation by CEC and to be model cases for electrification projects by CEC.

1) Micro-Hydro Pilot Projects

It is recommended that two pilot projects be implemented: Bu Sra scheme and Phase 2 of Samlout hybrid scheme[75]. MIME will be an executing agency and the pilot projects should be implemented on a semi-force account system[76]. MIME has study and planning experience with micro-hydro projects but does not have experience for design and construction supervision. In addition to financial support, technical assistance will be required. Implementation on a semi-force account system aims at capacity building of MIME staff on top of the implementation of the pilot projects. Therefore, it is recommended, from viewpoints of economic effect and capacity building effect, that the Bu Sra scheme be first implemented and then Phase 2 of the Samlout scheme.

Source: JICA study team

Figure 2.2.21 Power Station Site of Bu Sra Project

The Bu Sra project has one of the highest ratings for economic efficiency but the people's ability-to-pay is

70 For the Pramaoy micro-hydro scheme, it is planned, as a result of a study of alternatives, that a 25 kW biomass generator be installed in Phase 1 and another in Phase 2. If the daytime demand grows significantly by the time of Phase 2 planning, it is advised that the feasibility of micro-hydro should be reviewed again as a source of base power in Phase 2.

71 Pre-feasibility studies were conducted on two biomass schemes (Kampong Kor and Samraong). In addition, two biomass schemes, one each in Phase 1 of the Samlout hybrid scheme and in Phase 1 of the Pramaoy scheme, are included. The total number of biomass schemes has become four.

75 Phase 1 of the Samlout hybrid scheme is with biomass power.

76 Construction works include penstock installation works on the cliff downstream of the Bu Sra Waterfalls and river crossing structures across the Sangke River having a large catchment area of 438 km^2. In view of the construction works that require high level of construction know-how, special construction guidance services will be required in addition to construction works by local contractors. For the Bu Sra scheme, the road access from the provincial capital Sen Monorom is quite important as a lifeline of the region. For this, extensive road improvement works will be required including construction of a bridge upstream of the Bu Sra Waterfalls. These works would require capital costs more than the project costs. To cope with such issues that are expected to be faced in the implementation stage as road improvement works and delay in construction works due to flooding, a flexible financing and implementation system will be required.

79 The priority is to be in the ability-to-pay and the will to electrify.

the lowest among the pilot projects. If the project can be implemented as a pilot project, mainly aiming at capacity building, the poor villages in the remote area can be electrified. Most of the eco-tourists targeting the Bu Sra Waterfalls, which are the community's valuable tourism resource, and the virgin forests, come from the provincial capital, Sen Monorom, and return within the same day. After electrification, eco-tourists could stay for a few days in the Bu Sra villages and it would contribute to development of the villages.

The micro-hydro component of the Samlout project, Phase 2, is to be one of the backbone power stations of the Samlout regional mini-grid. Its characteristics are to supply electricity to regions with more than 6,000 households, not only for night-time but also for daytime demand with 24 hour supply. However, construction costs amount to as high as $13,000/kW. Therefore, the micro-hydro scheme should be commissioned at a time when the regional mini-grid covers the whole target area, to supply daytime demand in order to achieve the highest economic efficiency. In this case, it is possible to supply electricity at a low rate of about 20 cents/kWh. Accordingly, Phase 1 of the Samlout project will implement a biomass power plant (60 kWe x 2 units) with distribution lines.

The total construction costs of the two projects amount to $5.3 million.

Source: JICA study team

Figure 2.2.22 Sangke River of Samlout MHP

2) Biomass Pilot Projects

The JICA study team recommends that biomass gasification power be employed as the energy source of mini-grids in the plain regions after implementation of pilot projects to confirm its applicability (in terms of management by CEC) and solution of technical issues.

It is recommended that the biomass mini-grid pilot projects be implemented in 4 locations at Kampong Kor, Samlout Phase 1, Pramaoy Phase 1, and Samraong in an order of priority[79]. Implementation body of the pilot projects should be MIME but after completion the management will be entrusted to the relevant CEC[80]. As there is no engineer in MIME who has experience on biomass gasification power and fuel wood farming, technical assistance is necessary in its feasibility study, design, procurement, and construction stages, in addition to financial support. The total construction costs of the four biomass pilot projects amount to $1.6 million.

The pilot projects aim at nationwide public relations on electrification with biomass technology jointly with the existing Anlong Ta Mei village project, two pilot projects being planned by MIME in parallel with the Study, and two projects planned by NGOs[83]. In addition, these biomass pilots are to

[80] It is recommended for the Samlout scheme that covers a wide area with a regional mini-grid, that the power stations and 22 kV sub-transmission lines are owned and operated and maintained by a regional power company (RPC) and the low voltage distribution lines by the CEC. RPC should be selected through open tendering by DIME.

[83] One is an extension plan of the existing Anlong Ta Mey village electrification project.

demonstrate operation with various sizes, from small to large scale, with various business models and to further verify the technical issues.

Source: JICA study team

Figure 2.2.23 Tree-lined Street in Kampong Kor Village and Water Supply Barrow

The pilot projects aim at the following four:[85]

1) To verify applicability of biomass power to rural electrification (setting up and management of a CEC, technical issues and their solutions);

2) To foster human resources to lead CECs/REEs in the implementation of succeeding projects after the pilots through engaging MIME/DIME staff and related NGOs in the implementation and management of the pilot projects;

3) Public relations and demonstration of biomass electrification projects[86]; and

4) Based on the know-how and experience derived through the pilot projects, to discuss with manufacturers toward quality assurance of gasifiers in Cambodia, involving licensed or joint manufacturing in Cambodia.

3) Pilot Project of Solar BCS

It is proposed that a solar BCS pilot project be installed in Srae Ta Pan village. In this village, the penetration level of battery lighting is about 5% and the project can be a model of *Social Electrification*. Use of small capacity 6V batteries has penetrated to almost all the households as a substitute for torch light. However, the penetration level of 12 V batteries for home lighting is low because of the difficulties in finding the initial purchase cost (at about $25). Further, as the village is geographically separated into two groups, upstream and downstream, it is necessary to discuss and decide at village meetings whether to install a 4 kWp BCS in one location or two 2 kWp small BCSs, one in each of the two locations. This will also be a model case for setting up and management of a CEC.

The construction cost amounts to $32,000.

85 Verification themes of the pilot projects are presented in Attachment-12.

86 The study team propose that the operating surplus from the pilot projects, together with grant projects, after deducting expenses and reserves for future replacement of equipment from the operating income, be allocated in the future to DIME for its enlightenment and support activities for CECs.

88 The amount of cross subsidy was estimated by the study team assuming a tariff surcharge at 1.5% on the electricity tariff of EdC. EdC's forecast of electricity sales towards 2015 was applied to the estimate.

Source: JICA study team

Figure 2.2.24 Srae Ta Pan Village

2.2.3 Mid-term Policy Measures for Promotion of Rural electrification

In order to accelerate electrification projects after 2009, the following mid-term policy measures are recommended:

MP1 Start Operation of Cross-Subsidy System

After implementation of the cross subsidy system, more than $2 million is expected annually. The cost of a biomass electrification project for 300 households is around $0.2 million. If this amount is allocated as a 25% subsidy to the capital cost, 40 such projects per year could be provided with a 25% subsidy.

MP2 Establish and Start Complementary Functions to Existing REF

The proposed Complementary Functions to REF (CFR) should start its services in full swing from the year 2009 or even earlier. The total required capital for the off-grid electrification is about $147 million. Table 2.2.9 shows a potential arrangement of the capital costs.[88]

Table 2.2.9 Potential Arrangement of Capital Costs for Off-grid Electrification

No.	Sources	Amount (mil. $)
1	Tax exemption	13
2	CEC/REE equity（15-25% after tax exemption）	34
3	Cross subsidy from the grid users (1.5% of tariff)	40
4	Long term and low interest loan from donors	30
5	Repayment from CEC/REE to loans（2010-2020）	30
6	Grants of existing REF	7.5
Total		**154.5**

Source: JICA study team

In Table 2.2.9, it is assumed that resourced loans from donor countries are applied as soft loans to CECs/REEs to cover 60% of the capital costs. After commissioning, loan repayment from CECs/REEs starts and a revolving effect can be expected. On assumptions that an initial fund of $30 million is fully repaid in 15 years time and that it is re-lent as a revolving fund, another $30 million will be accumulated from the repayments and can theoretically be allocated to relending.

For the off-grid electrification, CFR requires a fund source for a loan of around 30 million dollars and a 30 to 40 year period of repayment with a low interest rate. If the revolving effect is realized as mentioned above[90], most of the required capital can be covered together with government finance[91].

MP3 Start Project Implementation in Full Swing

The pilot projects implemented in the Electrification Phase 1 (2005-2008) should be monitored for further lessons on management by CEC and operation and maintenance of the biomass gasifier power including fuel tree farming. Based on these lessons, an implementation program of the off-grid electrification should be prepared including a financial support plan of REF and CFR.

In parallel with implementation of the off-grid electrification, the following issues should be further studied and countermeasures prepared and executed:

1) Reinforcement of related authorities including supervisory ministries and agencies;

2) Examination of allocation of the government finance and arrangements for obtaining ODA support;

3) Development and reinforcement of the private financial system in Cambodia;

4) Support for fostering and reinforcing the implementation body (CEC/REE); and

5) Exemption from corporate tax (MEF)

2.2.4 Perspective of Achieving Electrification Targets

As for implementation of the National Electrification Program, such extensive foreign support as obtained for urgent improvement of the power supply to the Phnom Penh area in the past could not be expected and would gradually decrease. Self-support efforts by RGC and the people become more and more important.

If the grid electrification is solely financed by domestic resources and committed financial support[94], that is, proposed tax exemption for renewable energy equipment ($13 million), cross subsidy from the grid users ($40 million[95]), and REF fund which has already been committed ($7.5 million), the village electrification level[96] in 2020 would remain at 57.5% and the household electrification level at 43.1%, even with an assumption that the target levels for grid electrification is achieved having separate finance.

If financial support of $30 million (low interest rate, 40 year repayment period with a grace period of 10 years) is provided by donors in addition to the domestic resources mentioned above and is re-lent to CECs/REEs as two step loans (with an assumed repayment period of 15 years), then the revolving effect

90 Actually financial demand will increase through the risks of relending loss.
91 In order to facilitate the repayment by the government, a grace period of 10 years is desirable.
94 The improving share of 24% in the level of household electrification (2005 – 2020) was estimated in the MP on an assumption that the grid electrification will be separately and fully financed.
95 Estimated by the JICA study team on an assumption that a surcharge of 1.5% on the electricity tariff of EdC is raised as a fund for cross subsidy and based on EdC's energy selling forecast to 2015.
96 In Cambodia, it is defined that a village is electrified when more than 50% of the households in the village are electrified by one of the following two electrification methods:
1) A part of the village is electrified by the grid or decentralized mini-grids licensed by EAC (including mini-grids licensed by DIME before establishment of EAC in 2001 but not licensed yet by EAC); or
2) Electrified by self-generators or battery lighting.
100 Including solar BCS.

would facilitate the second support to CECs/REEs at the same $30 million level. The total supporting amount to CECs/REEs would amount to $60 million. By adding this to the estimated electrification levels above, it would become possible to improve the village electrification level up to 96.5%[100] and the household electrification level to the target at 47.0%[101].

2.2.5 Capital Requirement and Financing Plan

(1) Goals and Investment Costs

Basic goals are set out as follows:

- Final goal for 2030: to achieve 70% household electrification rate with grid quality
- Intermediate goal for 2020: to achieve 100% village electrification

Indicative investment cost of final goal by 2030

Indicative investment costs by type of electrification for achieving the 100% village electrification by 2030 are estimated as shown below.

Table 2.2.10 Indicative Investment Costs for Final Goal by 2030

Type of Electrification	No. of Candidate Villages (nos)	No. of total households of candidate villages (h.h.)	No. of h.h. to be electrified by year 2030 (h.h.)	Share of Total HHs (%)	Direct Cost per h.h. (US$/h.h.)	Direct Cost ($1,000)	Indirect Cost * 15% ($1,000)	Total Cost ($1,000)	Total Cost per h.h. (US$/h.h.)
Solar BCS	1,720	237,570	60,000	2.4	305	18,300	2,745	21,045	351
Indivisual SHS (World Bank Plan)			12,000	0.5	400	4,800	720	5,520	460
Grid Extension	753	208,520	847,537	33.9	406	344,100	51,615	395,715	467
Grid extension or Biomass Power	3,257	504,397							
Grid extension or Diesel Power	1,875	294,374							
Micro Hydro/Hybrid of Micro Hydro & Biomass	137	18,541	14,833	0.6	1,069	15,856	2,378	18,235	1,229
Biomass Power	3,071	501,636	401,309	16.1	515	206,674	31,001	237,675	592
Diesel Power	392	69,390	55,512	2.2	369	20,484	3,073	23,557	424
Sub total (W/O Solar)	9,485	1,596,858	1,319,191	52.8	445	587,114	88,067	675,182	512
Total	11,205	1,834,428	1,391,191	55.6	439	610,214	91,532	701,747	504

* Includes soft costs such as design, supervision, administration and contingency

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

(Source: JICA Study Team)

101 Households electrified to the grid quality by the National Grid or mini-grids, excluding solar BCS and SHS.

104 According to the village survey, the reality is that candidates for REE are difficult to find. Therefore, as a result of this, it is envisaged that the CEC will hold a major portion of the ownership.

Indicative investment cost of intermediate goal by 2020

The number of total households to be electrified by year 2020 is assumed as follows:

1) Grid / mini-grid (other than Solar): 32% of 2.5 million h.h.(total national HHs) = 800,000 h.h., with the following breakdown:
   - REE grid extension: 24% x 2,500,000 h.h. = 600,000 h.h.
   - Micro Hydro mini-grid: 50% x 18,541 h.h. = 9,000 h.h.
   - Biomass Power mini-grid: 33% x 501,636 h.h. = 168,000 h.h.
   - Diesel Power mini-grid: 33% x 69,390 h.h. = 23,000 h.h.

2) Solar: 12,000 + 25% x 237,570 h.h. = 72,000 h.h.

Indicative investment costs by type of electrification for the intermediate goal by 2020 are estimated as shown below.

Type of Electrification	No. of Candidate Villages (nos)	No. of total households of candidate villages (h.h.)	No. of h.h. to be electrified by year 2020 (h.h.)	Share of Total HHs * (%)	Direct Cost per h.h. (US$/h.h.)	Direct Cost ($1,000)	Indirect Cost * 15% ($1,000)	Total Cost ($1,000)	Total Cost per h.h. (US$/h.h.)
Solar BCS	1,720	237,570	60,000	2.4%	305	18,300	2,745	21,045	351
Indivisual SHS (World Bank Plan)			12,000	0.5%	400	4,800	720	5,520	460
REE Grid Extension	753	208,520	600,000	24.0%	406	243,600	36,540	280,140	467
Grid expansion or Biomass Power	3,257	504,397							
Grid expansion or Diesel Power	1,875	294,374							
Micro Hydro/Hybrid of Micro Hydro & Biomass	137	18,541	9,000	0.4%	1,069	9,621	1,443	11,064	1,229
Biomass Power	3,071	501,636	168,000	6.7%	515	86,520	12,978	99,498	592
Diesel Power	392	69,390	23,000	0.9%	369	8,487	1,273	9,760	424
Sub total (W/O Solar)	9,485	1,596,858	800,000	32.0%	435	348,228	52,234	400,462	501
Total	11,205	1,834,428	872,000	34.9%	426	371,328	55,699	427,027	490

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

(Source: JICA Study Team)

Table 2.2.11 Indicative Investment Costs for Intermediate Goal by 2020

The direct cost per household is estimated as shown below:

Table 2.2.12 Estimation of Investment Costs for Final Goal

Type of Electrification	No. of total households of candidate (h.h.)	No. of h.h. to be electrified by year 2020 (h.h.)	Installed Capacity (KW)	Average Gen. Equip. Costs (US$/KW)	Cost of Gen. Equip.*** (US$1,000)	Back up (US$1,000)	Length of MV Lines (km)	Length of LV Lines (km)	MV & LV Lines** (US$1,000)	Set-up Transformer (US$1,000)	Distribution Transformer (US$1,000)	Service Wire, Meter, In-house Wire, Etc. (US$1,000)	Direct Costs (US$1,000)	Direct Cost per h.h. (US$/h.h.)
Solar BCS	237,570	60,000											18,300	305
Indivisual SHS (World Bank Plan)		12,000											4,800	400
REE Grid Extension	208,520	804,845	104,647	1,311	137,192	0	4,101	12,098	110,502	0	38,719	40,289	326,702	406
Grid expansion or Biomass Power	504,397													
Grid expansion or Diesel Power	294,374													
Micro Hydro/Hybrid of Micro Hydro & Biomass	18,541	14,833	1,192	4,294	6,917	1,365	359	504	5,732	386	714	743	15,857	1,069
Biomass Power	501,636	804,845	104,647	1,950	204,062	0	4,101	12,098	110,502	20,929	38,719	40,289	414,501	515
Diesel Power	69,390	804,845	104,647	830	86,857	0	4,101	12,098	110,502	20,929	38,719	40,289	297,296	369

* Grid Extension, Biomass, Diesel : Direct Costs per h.h. are calculated in same conditions
** MV lines (US$6,000/km), LV lines (US$7,101/km)
*** Including Constraction Costs
**** Indirect costs (technical suport, administration and contingency)
(Source JICA Study Team)

The financing framework is assumed to be as shown in following table based on the discussions of Sub-section 1.7.3.

Table 2.2.13 Financing Framework for Rural Electrification

Type of Electrification	Scope of Work	Ownership	Funding Modality of Capital Costs	
1. National grid extension	Grid extension to priority supply and high demand areas	EdC	Equity (30%), Loan (70%)	
			REE	CEC
2. Extension of REE grid	Rehabilitation of Distribution lines and Extension of an existing mini grid systems	REE	Subsidy (25%), Equity (15%), Soft Loan (60%)*	-
3. Renewable Energy new mini grid (Hydro)	Generation and distribution	REE/CEC	Subsidy (25%), Equity (15%), Soft Loan (60%)	Subsidy (50%), Equity (10%), Soft Loan (40%)
4. Renewable Energy new mini grid (Biomass)	Generation and distribution	REE/CEC	Subsidy (25%), Equity (15%), Soft Loan (60%)	Subsidy (25%), Equity (15%), Soft Loan (60%)
5. Diesel new mini grid	Generation and distribution	REE/CEC	Subsidy (25%), Equity (25%), Soft Loan (50%)	Subsidy (25%), Equity (25%), Soft Loan (50%)
6. Solar system	SHS,BCS	REE/CEC	Subsidy (25%) Equity (15%), Soft Loan (60%)	Subsidy (95%), Equity (5%), Soft Loan (0%)
	Remote & Social electrification by solar power	Public (Owned by a Renewable Energy Center (REC)	Grant (95%), Equity (5%)	

(Note) * Expected interest rate is around 3-7% depending on the scheme.
Source: JICA Study Team

(2) Funding Plan

An indicative financing plan by type of electrification is given in the following table, which is obtained by combing Table 2.2.11 and Table 2.2.13. Ownership rates are assumed as follows:

Solar BCS: All ownership of Solar BCS is to be CEC

Micro Hydro: 70% of ownership of Micro Hydro is CEC

Biomass Power: 60% of ownership of Biomass Power is REE[104]

Diesel Power: 70% of ownership of Diesel Power is REE

Table 2.2.14 Indicative Financing Plan by Fund Sources for Intermediate Goal

Type of Electrification	No. of h.h. to be electrified by year 2020	Total Cost	Total Cost per h.h.	Ownership*		Capital Cost classified by Ownership	Fund Source of Capital Costs (%)			Fund Source of Capital Costs ($1,000)		
	(h.h.)	($1,000)	.)		(%)	($1,000)	Subsidy	Equity	Loan	Subsidy	Equity	Loan
Solar BCS	60,000	21,045	351	REE	0%	0	25%	15%	60%	0	0	0
				CEC	100%	21,045	95%	5%	0%	19,993	1,052	0
Indivisual SHS (World Bank Plan)	12,000	5,520	460	Personal	100%	5,520	25%	25%	50%	1,380	1,380	2,760
REE Grid Extension	600,000	280,140	467	REE	100%	280,140	25%	15%	60%	70,035	42,021	168,084
Grid expansion or Biomass Power												
Grid expansion or Diesel Power												
Micro Hydro & Biomass	9,000	11,064	1,229	REE	0%	0	25%	15%	60%	0	0	0
				CEC	100%	11,064	50%	10%	40%	5,532	1,106	4,426
Biomass Power	168,000	99,498	592	REE	60%	59,699	25%	15%	60%	14,925	8,955	35,819
				CEC	40%	39,799	25%	15%	60%	9,950	5,970	23,880
Diesel Power	23,000	9,760	424	REE	70%	6,832	25%	25%	50%	1,708	1,708	3,416
				CEC	30%	2,928	25%	25%	50%	732	732	1,464
Sub total (W/O Solar)	800,000	400,462	501			400,462				102,882	60,492	237,088
Total (W/Solar)	872,000	427,027	490			427,027				124,254	62,924	239,848
									sub-total (w/o Solar)	26%	15%	59%
									Total (W/Solar	29%	15%	56%

* Ownership rates are assumption, rates will be change by further examination

(Source: JICA Study Team)

A Phased Investment Plan

A phased investment plan by electrification type for intermediate goal is given the following table. The simulation is based on following assumptions:

The progress of electrification is assumed to be in four phases as follows:

1st Phase (2005-2008): 15% (The first stage where electrification starts up)

2nd Phase (2009-2012): 25% (The second stage where electrification gets into stride)

3rd Phase (2013-2016): 30% (The third stage which electrification accelerates)

4th Phase (2017-2020): 30% (The fourth stage which electrification accelerates)

Table 2.2.15 Phased Investment Plan by Electrification Type

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	Phased investment ($1,000)			
	(h.h.)	(h.h.)	(%)	2005-2008 15%	2009-2012 25%	2013-2016 30%	2017-2020 30%	(US$/h.h)	(US$1,000)	2005-2008 15%	2009-2012 25%	2013-2016 30%	2017-2020 30%
Solar BCS	237,570	**60,000**	2.4%	9,000	15,000	18,000	18,000	351	21,045	3,157	5,261	6,314	6,314
Indivisual SHS (World Bank Plan)		**12,000**	0.5%	6,000	6,000	0	0	460	5,520	2,760	2,760	0	0
Grid Extension	208,520	**600,000**	24.0%	90,000	150,000	180,000	180,000	467	280,140	42,021	70,035	84,042	84,042
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	1,660	2,766	3,319	3,319
Biomass Power	501,636	**168,000**	6.7%	25,200	42,000	50,400	50,400	592	99,498	14,925	24,875	29,849	29,849
Diesel Power	69,390	**23,000**	0.9%	3,450	5,750	6,900	6,900	424	9,760	1,464	2,440	2,928	2,928
Sub total (W/O Solar)	1,596,858	**800,000**	32.0%	120,000	200,000	240,000	240,000		400,462	60,069	100,116	120,139	120,139
Total (W/Solar)	1,834,428	**872,000**	34.9%	135,000	221,000	258,000	258,000		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)

Simulation of phased investment plan

Three cases of phased investment plan are simulated by type of fund as follows:

Case1 (Constant Subsidy Case):
Subsidy rate will be fixed until 2020

Case2 (Minimizing Subsidy Case):
The case expected from private investment and gradually development of financial mechanism. Subsidy rate will be gradually decreased and Equity and Loan will be increased.

Case 1: A phased investment plan by type of fund (Constant Subsidy Case) is given in the below table.

Table 2.2.16 Phased Investment Plan by Fund Sources (Constant Subsidy Case)

Type of Electrification	Ownership (%)		Disbursement (%)											
			2005-2008			2009-2012			2013-2016			2017-2020		
			Subsidy	Equity	Loan	Subsidy	Equity	Loan	Subsidy	Equity	Loan	Subsidy	Equity	Loan
Solar BCS	REE	0%	25%	15%	60%	25%	15%	60%	25%	15%	60%	25%	15%	60%
	CEC	100%	95%	5%	0%	95%	5%	0%	95%	5%	0%	95%	5%	0%
Indivisual SHS (World Bank Plan)	Personal	100%	25%	25%	50%	25%	25%	50%	25%	25%	50%	25%	25%	50%
Grid Extension / Grid extension or Biomass Power / Grid extension or Diesel Power	REE	100%	25%	15%	60%	25%	15%	60%	25%	15%	60%	25%	15%	60%
Micro Hydro & Biomass	REE	0%	25%	15%	60%	25%	15%	60%	25%	15%	60%	25%	15%	60%
	CEC	100%	50%	10%	40%	50%	10%	40%	50%	10%	40%	50%	10%	40%
Biomass Power	REE	60%	25%	15%	60%	25%	15%	60%	25%	15%	60%	25%	15%	60%
	CEC	40%	25%	15%	60%	25%	15%	60%	25%	15%	60%	25%	15%	60%
Diesel Power	REE	70%	25%	25%	50%	25%	25%	50%	25%	25%	50%	25%	25%	50%
	CEC	30%	25%	25%	50%	25%	25%	50%	25%	25%	50%	25%	25%	50%
Total			29%	15%	56%	29%	15%	56%	29%	15%	56%	29%	15%	56%

Type of Electrification	Ownership (%)		Prased 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 / Grid extension or Biomass Power / Grid extension or Diesel Power	REE	100%	10,505	6,303	25,213	17,509	10,505	42,021	21,011	12,606	50,425	21,011	12,606	50,425	70,035	42,021	168,084
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	3,731	2,239	8,955	4,477	2,686	10,746	4,477	2,686	10,746	14,925	8,955	35,819
	CEC	40%	1,492	895	3,582	2,487	1,492	5,970	2,985	1,791	7,164	2,985	1,791	7,164	9,950	5,970	23,880
Diesel Power	REE	70%	256	256	512	427	427	854	512	512	1,025	512	512	1,025	1,708	1,708	3,416
	CEC	30%	110	110	220	183	183	366	220	220	439	220	220	439	732	732	1,464
Total			19,121	9,922	36,943	31,409	16,076	60,652	36,862	18,463	71,127	36,862	18,463	71,127	124,254	62,924	239,848
															Percent Share		
															29%	15%	56%

(Source: JICA Study Team)

Case 2: A phased investment plan by type of fund (Minimizing Subsidy Case) is given in the below table.

Table 2.2.17 Phased Investment Plan by Fund Sources (Minimizing Subsidy Case)

Type of Electrification	Ownership (%)		Disbursement (%) 2005-2008 Subsidy	Equity	Loan	2009-2012 Subsidy	Equity	Loan	2013-2016 Subsidy	Equity	Loan	2017-2020 Subsidy	Equity	Loan
Solar BCS	REE	0%	25%	15%	60%	20%	15%	65%	10%	20%	70%	0%	25%	75%
	CEC	100%	95%	5%	0%	95%	5%	0%	95%	5%	0%	95%	5%	0%
Indivisual SHS (World Bank Plan)	Personal	100%	25%	25%	50%	25%	25%	50%	25%	25%	50%	25%	25%	50%
Grid Extension / Grid extension or Biomass Power / Grid extension or Diesel Power	REE	100%	25%	15%	60%	20%	15%	65%	10%	20%	70%	0%	25%	75%
Micro Hydro & Biomass	REE	0%	25%	15%	60%	20%	15%	65%	10%	20%	70%	0%	25%	75%
	CEC	100%	50%	10%	40%	50%	10%	40%	50%	10%	40%	50%	10%	40%
Biomass Power	REE	60%	25%	15%	60%	20%	15%	65%	10%	20%	70%	0%	25%	75%
	CEC	40%	25%	15%	60%	20%	15%	65%	15%	15%	70%	10%	15%	75%
Diesel Power	REE	70%	25%	25%	50%	20%	25%	55%	10%	20%	70%	0%	25%	75%
	CEC	30%	25%	25%	50%	20%	25%	55%	15%	25%	60%	10%	25%	65%
Total			29%	15%	56%	25%	15%	61%	16%	19%	66%	7%	23%	70%

Type of Electrification	Ownership (%)		Phased Investment Costs (US$1,000) 2005-2008 Subsidy	Equity	Loan	2009-2012 Subsidy	Equity	Loan	2013-2016 Subsidy	Equity	Loan	2017-2020 Subsidy	Equity	Loan	Investment Cost(US$1,000 2005-2020 Total 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 / Grid extension or Biomass Power / Grid extension or Diesel Power	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
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)

Indicative subsidy requirement

Indicative investment plans by fund sources in above two subsidy types are given in the following table.

Table 2.2.18 Indicative Investment by Fund Sources in Three Subsidy Types

Type of Electrification	Ownership (%)		Constant Subsidy Case Total Investment ($1,000) Subsidy	Equity	Loan	Minimizing Subsidy Case Total Investment ($1,000) Subsidy	Equity	Loan
Solar BCS	REE	0%	0	0	0	0	0	0
	CEC	100%	19,993	1,052	0	19,993	1,052	0
Indivisual SHS (World Bank Plan)	Personal	100%	1,380	1,380	2,760	1,380	1,380	2,760
Grid Extension / Grid extension or Biomass Power / Grid extension or Diesel Power	REE	100%	70,035	42,021	168,084	32,916	54,627	192,596
Micro Hydro/Hybrid of Micro Hydro & Biomass	REE	0%	0	0	0	0	0	0
	CEC	100%	5,532	1,106	4,426	5,532	1,106	4,426
Biomass Power	REE	60%	14,925	8,955	35,819	7,015	11,641	41,043
	CEC	40%	9,950	5,970	23,880	6,467	5,970	27,362
Diesel Power	REE	70%	1,708	1,708	3,416	803	1,606	4,424
	CEC	30%	732	732	1,464	476	732	1,720
Total			124,254	62,924	239,848	74,582	78,115	274,331
(Source: JICA Study Team)		Percent Share (%)	29%	15%	56%	17%	18%	64%

The main conclusions of the simulation are as follows:

- The subsidy requirement in Case1 is $124 million, which is not realistic. In the present situation that subsidy funds are not fully secured, possibility is very low.
- The subsidy requirement in Case2 is $74 million, which is more realistic. In the present situation that subsidy funds are not fully secured, this case will be realistic option.

Therefore, Case2 is recommended. As mentioned before, a key element of a long-term success in the development of the rural electrification will be providing an investment environment conducive to attracting private sector investors who will takes on an ever-increasing role in funding the sector while easing the fiscal burden of the fund-starving government. So gradual reduction in subsidies for profitable grid electrification is desired to attain self-standing and sustainable funding for the private sector oriented RE sector development.

(3) Sources of Funding

The possible sources for financial support facilities as discussed above are shown in the following table.

Table 2.2.19 Possible Funding Sources

Standard Case			Funding source	Advantage	Disadvantage	Note
REE*	Equity	15 %	- Private Fund (REE own fund)	- Incentive of service expansion and efficiency	- Tariff should make enough profit for REE	- Available
			- Partial investment from municipality, community and users	- Surveillance to management (advantage of users)	- Pressure to management of REE	- If possible
			- Foreign Direct investment by CDM scheme	- No financial burden	- Procedure is complexity and difficult - Expected benefit is small	- May be possible in the future, but not applicable under the present situation
	Subsidy	25 %	- REF	- No financial burden	- Fund is limited - Not continuous and not sustainable - Cause continued dependency and demand for donation	- Available
			- Donation	- No financial burden	- no commitment now - Not continuous and not sustainable	- Not available now
			- Tariff surcharge revied on existing customers**	- Continuous and sustainable - Gap correction between urban and rural	- Burden on existing user	- Appropriate and recommendable, but legal revision is required
			- Special Tax for imported home electronics	- Continuous and sustainable - Incentive for industrialization of home electronics	- Burden on home electronics buyers	- Appropriate and recommendable, but legal revision is required
			- Tax incentive for imported power equipments	- Continuous and sustainable	- Reduction in government finance	- Appropriate and recommendable, but tax reform is required
	Loan	60 %	- ODA loan (through RDB etc.)	- Low interest rate and long term	- Limited	- Appropriate and recommendable
			- Suppliers' credit	- Easier to apply than commercial bank - Export credit will be available	- Credible suppliers are limited - Need credit guarantee, mutual trust	- May be possible in the future
			- Commercial Banks	- High interest rate and short term	- Need guarantee, mutual trust	- May be available but not feasible now
CEC ***	Equity	15 %	- Village Fund - Collection from residents - Community budget	- Promote solidarity of community	- Limited	- May be available but limited
			- Labor force & materials	- Use own labor & materials to reduce cash payments	- Need certainly and continuous contribution for O&M is also required	- Available
	Subsidy	30 %	- Same as REE	- Same as REE	- Same as REE	- Same as REE
	Loan	55 %	- Same as REE	- Same as REE	- Same as REE	- Same as REE

* REE: REE owned by private
** See below preliminary study for tariff surchage
*** CEC: REE owned by CEC
(Source: JICA Study Team)

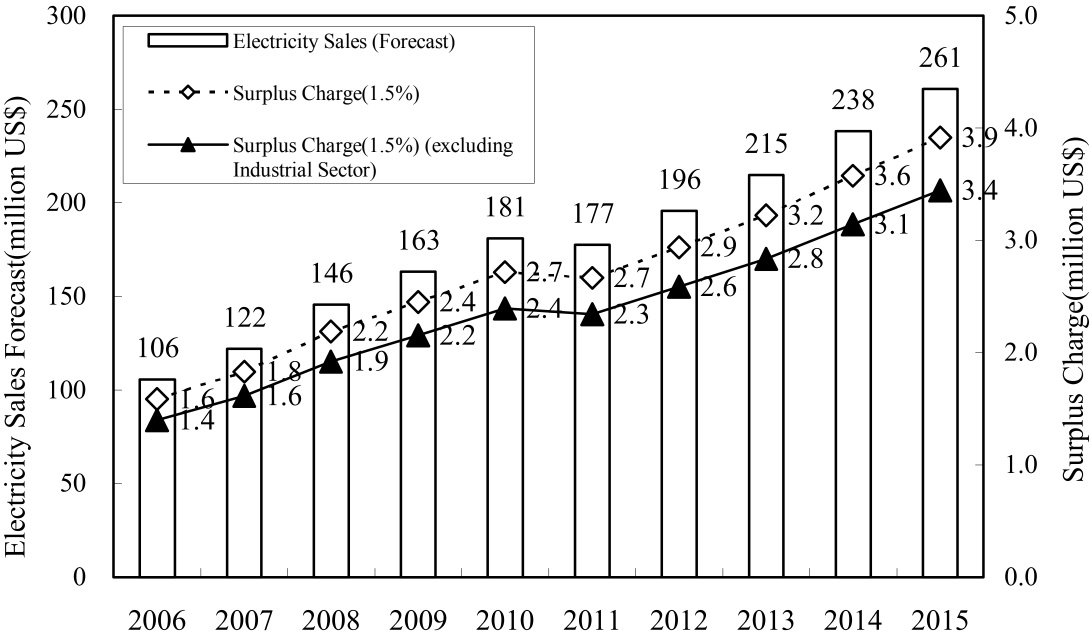
Preliminary study for tariff surcharge

Tariff surcharge is simulated with revision on existing customers of EdC as below. The simulation is based on following assumptions:

- Tariff surcharge rate : 1.5% of current tariff for all customers
- Share of Industrial Sector : 12% of total EDC sales
- EDC sales forecast:

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Electricity Sales ($ million)	106	122	146	163	181	177	196	215	238	261

(Source: EDC)



(Source: JICA Study Team)

Figure 2.2.25 Electricity Sales Forecast of EDC & Expected Surplus Change

As the annual average amount of tariff surcharge for the period 2006 to 2015 is $ 2.7 million. The total accumulated amount will be around $ 46 million for 15 years. If the industrial sector will be excluded from the object of tariff surcharge for the sake of industrial promotion, the annual average amount of tariff surcharge for the period 2006 to 2015 is $ 2.4 million and the total accumulated amount will be around $ 41 million for 15 years. On the other hand, forecast of generation and unit cost of power will go down 28% from year 2005 to year 2016 as shown below. The surcharge rate of 1.5% is small and acceptable compared with this cost down.

It is recommended that this tariff surcharge be one of the candidates for continuous and sustainable funding sources for subsidy.

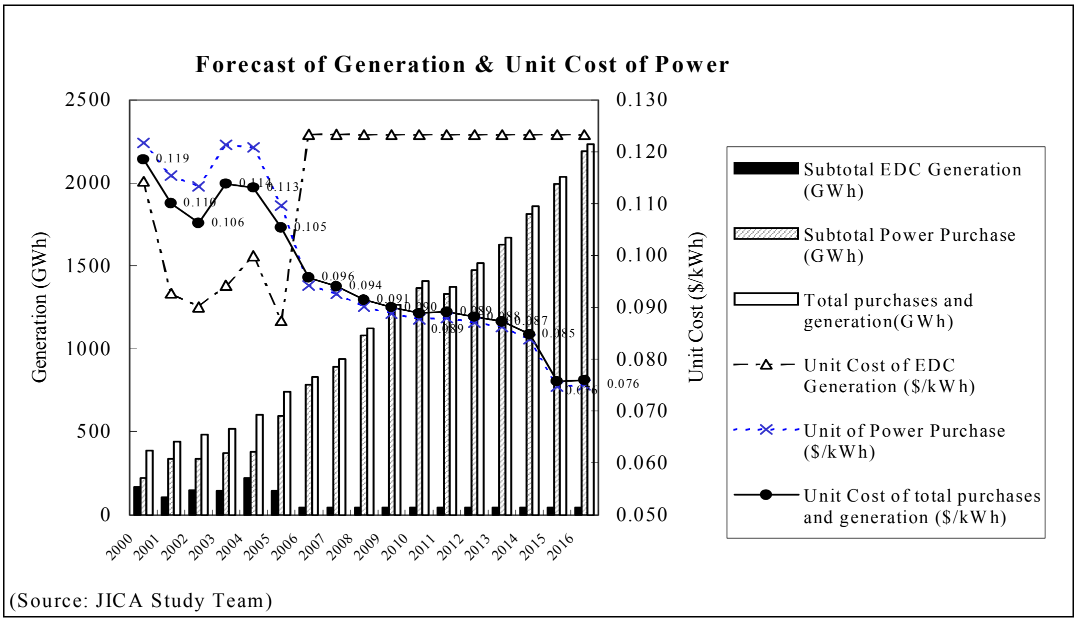


Figure 2.2.26 Forecast of Generation & Unit Cost of Power

2.2.6 Institution for Promoting Implementation of RE

The main RE components/sub-components, their implementation arrangements and the groups of households that are likely to take supply through them are summarized in the following table. This is based on the discussion of previous Chapter 2.1.

Table 2.2.20 Tentative Implementation Arrangements for RE Sector

System		RE Components	Generation Sources	Implemented/operated by:	Capital Fund Sources	Mainly directed at:
On-grid System		Network extension: from existing networks or from cross-border supplies	a. diesel b. hydro c. import	a. EdC b. EdC-REE c. REE	a. Budget b. ODA c. Private d. REF e. Tariff	Medium and high-income households, located in densely populated plain areas and within economic reach of supply (within 1 km of regional roads inside PAGE (40 km from GS))
Off-grid System	Mini Grid	REE-grid	a. diesel b. hydro c. biomass	REE	a. Private b. REF c. Tariff	Medium and high-income households, located in densely populated plain area and beyond economic limits of network extensions
		CEC-grid	a. diesel b. hydro c. biomass	Local-based cooperatives or association	a. ODA b. REF c. Local contribution d. Tariff	Medium and high-income households, located in more remote areas
	Stand-alone System	Individual household system	a. pico-hydro b. solar PV (SHS) c. diesel	a. Private sector (REE/REB) b. Local-based cooperatives or association	a. ODA b. REF c. Tariff d. Private	Medium and high-income households in plain areas (solar PV systems). Medium and low income households in remote, hilly areas (pico-hydro)
		Batteries	a. diesel b. solar PV	a. Private sector (REE/REB) b. Local-based cooperatives or association	a. ODA b. REF c. Tariff d. Private	Households affordable to buy own battery and to pay charging fee in non-electrified rural areas.

Source: JICA Study Team, Meritec Report (Final Report on Task V, p.8.3-8.4)