Table 3 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[32]. 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[33]	Supporting services in setting up and management of CEC and technical matters on contract basis with CEC[34]
7.	Suppliers etc.	Supply of equipment, repair of equipment on a fee basis after expiry of the guarantee period

Source: JICA study team

(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 4[35].

[32] 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 responsibility of a licensee or (2) the CEC can be registered as a company.

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

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

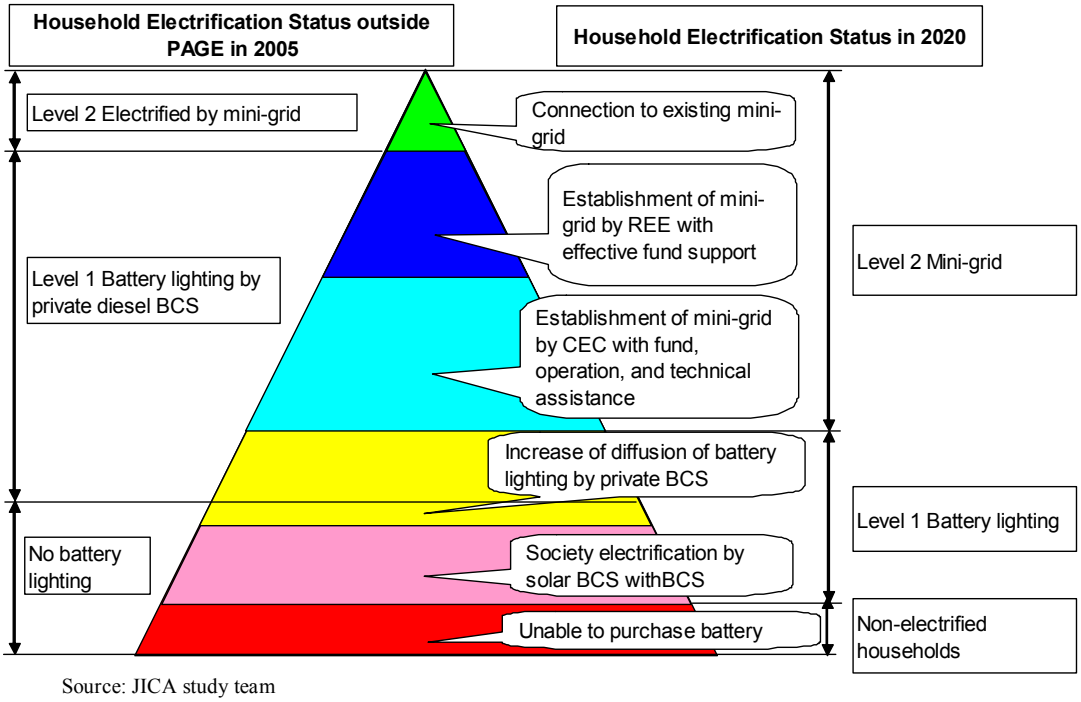
[35] In the table, a diesel generator is also included as a candidate energy source. In the suburbs of urban cities and in the plain areas along the Mekong River, there are those villages that have little potential for a micro-hydro and lack shrub-lands for biomass plantations. If electricity supply 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.

Table 4 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	Off-grid	2	100 (30-200 subject to village economic levels)	10	Decentralized mini-grid	Biomass gasification power, hourly supply depending on demand
	Outside PAGE	Off-grid	2	100 (30-200 subject to village economic levels)	10	Decentralized mini-grid	Diesel power, hourly supply depending on demand
	Outside PAGE	Off-grid	1	10 (40 for households with TV)	3	BCS, SHS for public facilities	Existing diesel power, Solar power

Source: JICA study team

Figure 14 illustrates applications of the three levels of electrification to non-electrified areas depending on the household income level as of 2005[36]. Figure 14 represents the area outside the PAGE, which covers the 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[37], 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.



Source: JICA study team

Figure 14 Present and Planned Levels and Types of Electrification Outside PAGE

[36] The area of each layer does not represent actual share ratio.

[37] 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.

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:

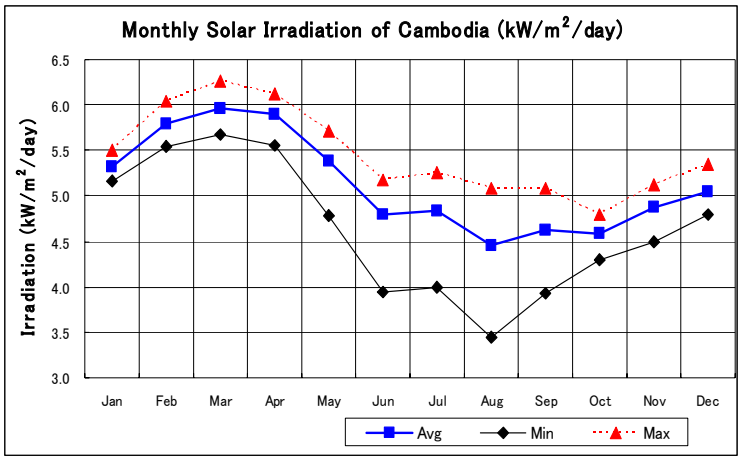
a) Renewable Energy Potential

The potential of renewable energy in the off-grid areas and its characteristics are presented in Table 5 and Figures 15 to 17[38]. Figure 15 shows the monthly variation of solar irradiation obtained from satellite data[39]. Black marks in Figure 16 show potential sites for micro-hydro and red lines environmental protection areas. Figure 17 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[40].

Table 5 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 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 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 local wind corridors.

Source: JICA study team



Source: Processed by JICA study team from NASA satellite data

Figure 15 Monthly Variation of Solar Irradiation in Cambodia

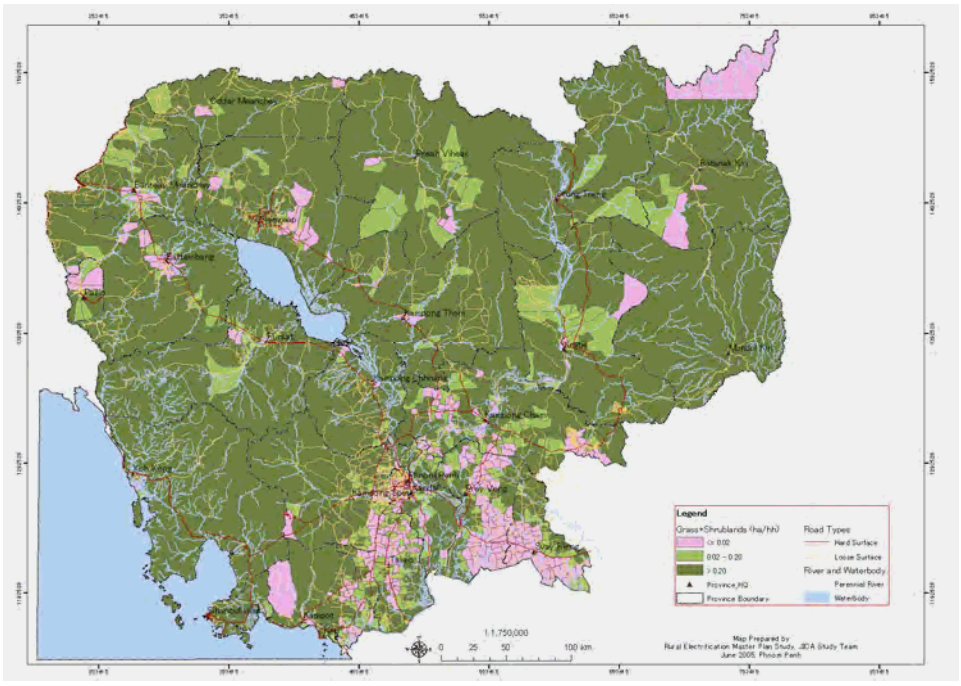
[38] It does not include such micro-hydro or wind power potential that would connect to the grid and feed its excess energy accordingly. Detailed information on this potential is presented in Attachment-10.

[39] 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.

[40] The forest cover areas in the north-eastern part etc. are also pink-colored in Figure 17. These are the results of GIS processing where, for convenience, those areas not inhabited are treated as not suitable for biomass power.

Source: JICA study team

Figure 16 Micro-hydro Potential and Environment Protected Areas



Source: JICA study team

Figure 17 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[41];
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 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[42].

In Cambodia, one small scale gasifier[43] 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 18).

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

Figure 18 Existing Rural Electrification by Biomass Power[44]

[41] In cases where agricultural waste like rice husk is available inside the community without conflict with existing users, and where such agricultural waste can be supplied stably in the long term and seasonally, such agricultural waste will be the first candidate for fuel.

[42] 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), and in Myanmar (135 sets in total, only since 2000, and of these 25 sets are for power generation). For details, refer to Vol-5 Appendices to sector study, Appendix-C.

[43] Continuous rated output is 7 kWe.

[44] The left hand side is the gasifier and the right hand side shows a fuel wood plantation.

As for biomass gasification power (BGP), the numbers of past installations and manufacturers 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 19). Biomass use is recognized as being able to create job opportunities, even in Europe and the US. Such an effect is expected in the rural area of Cambodia in particular.

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 the 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[45].

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 6, BGP satisfies the required conditions as an energy source for mini-grids[46] except for the arrangement of initial capital costs. In addition, if the plant factor[47] (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 23). 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.

[45] 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 Review Workshop, October 27, 2005, Phnom Penh, Cambodia.

[46] As for the three candidate power sources for mini-grids (micro-hydro, biomass, and diesel), a comparison table for appropriateness is shown in Attachment-11.

[47] The plant factor is 100% at full output operation for 24 hours every day, and 12% at 3.1 hours daily operation.

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

Figure 19 Fuel Wood Prepared for Gasifier

Table 6 Required Conditions as Energy Sources for Decentralized Mini-grids

No.	Item	Diesel	MHP	Solar	Biomass
1.	Operation and maintenance work 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[48]	P	P	P (Fuel wood farming)
3.	Investment cost can be recovered within the range of ability-to-pay ($3 to $5 per month).(Prerequisite conditions for investment)	P (Loan)	PWC (High ratio subsidy and soft loan)	PWC (100% subsidy for equipment)	PWC (Soft loan)
4.	Power generation at required scale (10-200 kWe) as a decentralized independent power system is possible.	P	P	D[49]	P
5.	Unit generation cost[50] ($/kWh)				
	Plant factor: 15%	0.59	0.85[51]	-	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[52] and solar in terms of renewable energy potential[53]. As BCSs are for rural villages where there is little penetration of battery lighting[54], the key factor is easiness of

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

49 Technically possible, but economically unrealistic.

50 Including tax, at the consumer end.

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

52 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.

53 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.

54 Those red points shown in the location map at the beginning of this report have been identified through the Study as candidates for battery lighting (Level 1 solar BCS). Solar BCS can be applied anywhere in the off-grid areas. These candidate villages were

operation and maintenance. Solar power does not require any generator (panel) operation, and is almost maintenance free[55]. On the other hand, biomass power generation is difficult to apply to remote small villages in view of the required output 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.

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[56]. 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[57] 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 7.

selected with criteria based on probability of grid extension, existence of mini-grids, level of electrification, and penetration level of TV (a substitute for battery penetration level and used as an indirect parameter to measure ability-to-pay). The 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.

55 After a target village is electrified with mini-grid or 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 CECs on nominal charge basis.

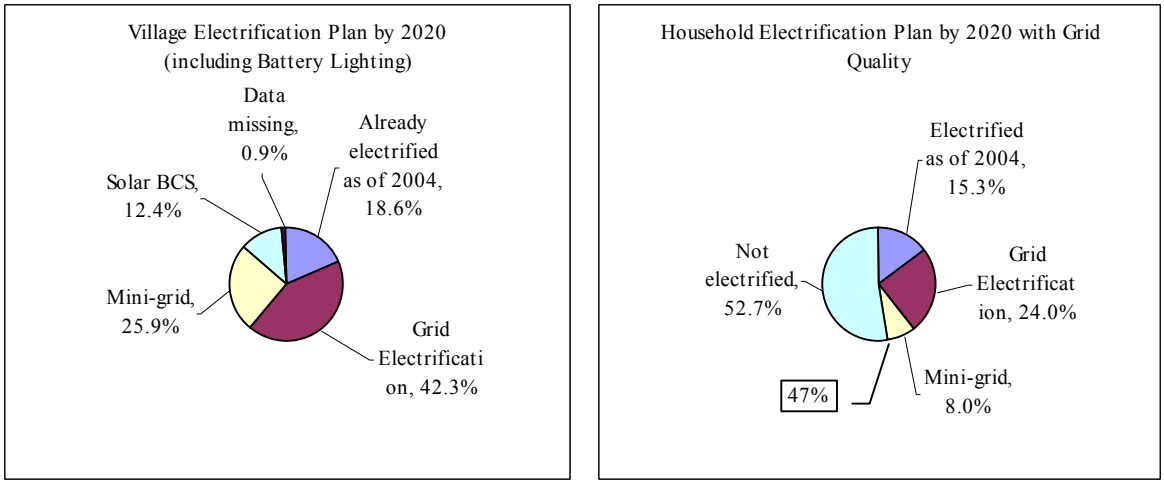
56 Diesel generators as a source for mini-grids have the same issues as the sources for BCSs.

57 From Seila village database 2003, published in 2004. The total number of villages was 13,914 in the MP including four villages newly established.

Table 7 Framework of Rural Electrification Program

Name of Representative Regions	Energy Sources	Number of Villages	Number of Households[58]	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[59] **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[60]	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



Source: JICA study team

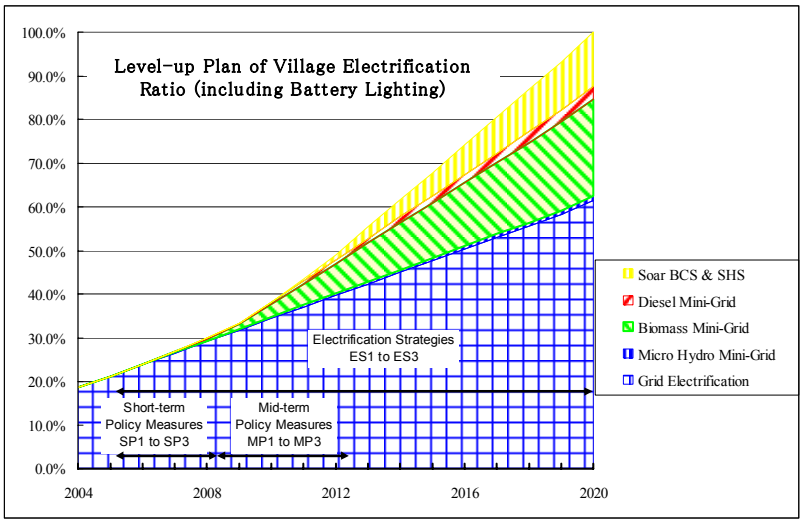
Figure 20 Constitution of Village and Household Electrification Plans by 2020

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

As shown on the left side of Figure 20, 100% (13,793) villages[61] will be electrified including solar BCS and SHS by the year 2020[62]. Shown on the right side are household electrification levels by the 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%.

Figure 21 shows an improvement plan of the village electrification level and Figure 22 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 22 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%[63] of the households in the off-grid areas. Therefore the impact of mini-grids on the off-grid areas will be significant.



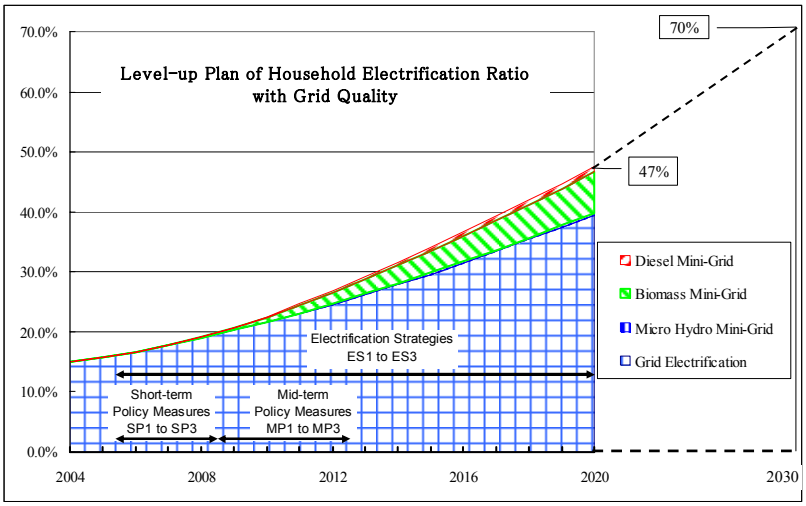
Source: JICA study team

Figure 21 Improvement in Village Electrification Level (including battery lighting)

61 Excluding 121 villages with village data not available.

62 For 1,720 villages with battery usage level lower than 20%, battery lighting will be promulgated with BCS and SHS. A total number of 72,000 households will be newly electrified. As battery lighting has been rapidly penetrating, the number of target villages for BCSs would decrease every year with monitoring of the progress of electrification through the Seila village survey.

63 From the total number of household for mini-grid in Table 7, 200,000/589,567 = 34%.



Source: JICA study team

Figure 22 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[64]:

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 8, 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 BCSs requires about $21 million ($351 per household). REF has a source of subsidy for 12,000 sets of SHS[65].

[64] 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 also be reviewed every 4 years 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.

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

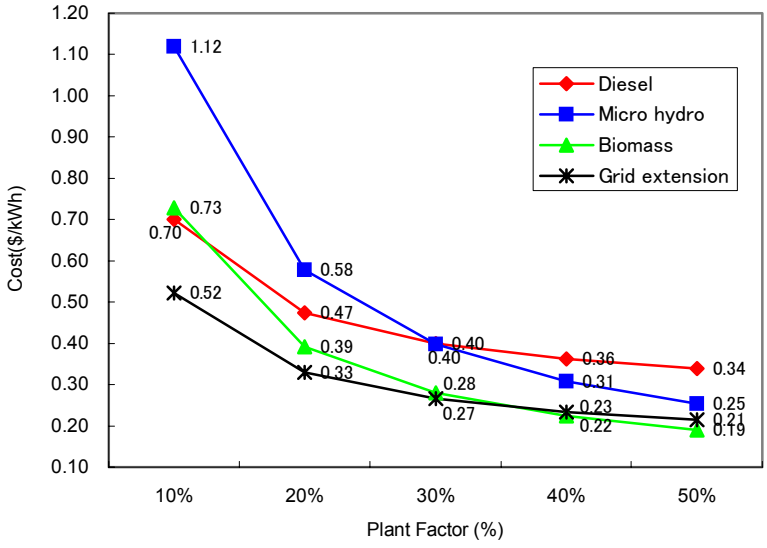
Table 8 Rural Electrification Plan and Financing Requirements

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[66]. 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[67]. Figure 23 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 23 Plant Factors and Unit Costs of Electricity at the Consumer End

[66] 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.

[67] 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.

(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 16. 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 Short-term Policy Measures

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:[68]

SP1 Financial Arrangements

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

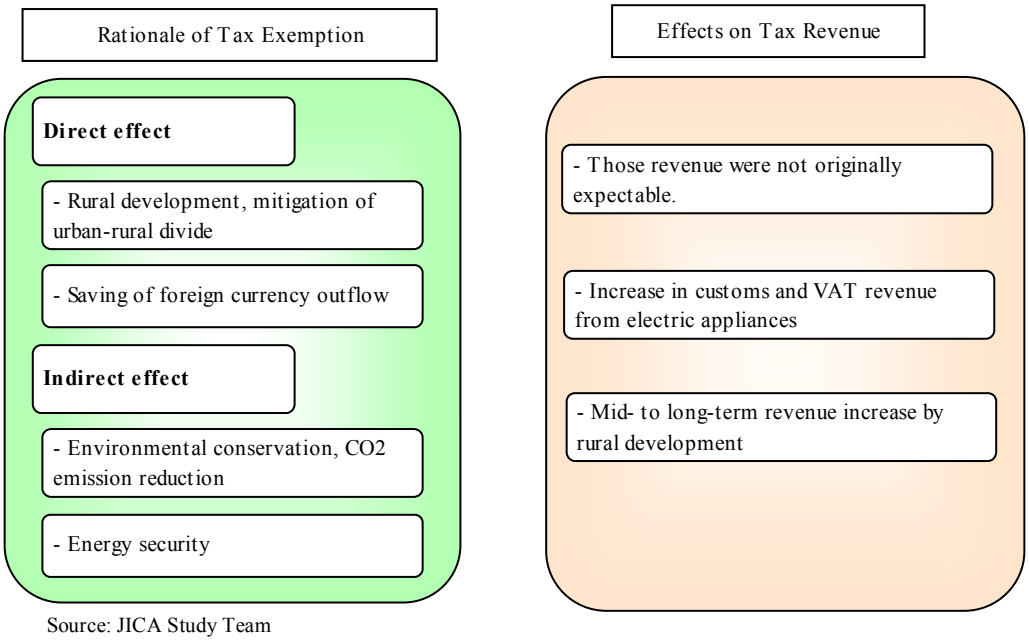
With limited financing resources available for subsidies to CECs/REEs, it is quite important for RGC, so as not to be depending on grants from donor agencies, to make every effort to arrange its own sources within Cambodia for such subsidies. The JICA study team recommends that MEF and MIME examine and create an exemption system from import customs and value added tax (VAT) on renewable energy equipment[69]. 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.

[68] The "Action Plan for the Promotion of Rural Electrification" and "Supporting System for Promotion of Rural Electrification", which are proposed by the study team, are presented in Attachments 7 and 8.

[69] 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.

The rationale of tax exemption for RGC and its influence on tax revenue are illustrated in Figure 24 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 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 24 Rationale of Tax Exemption and Effects on 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,[70] 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[71]) 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[72]. 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

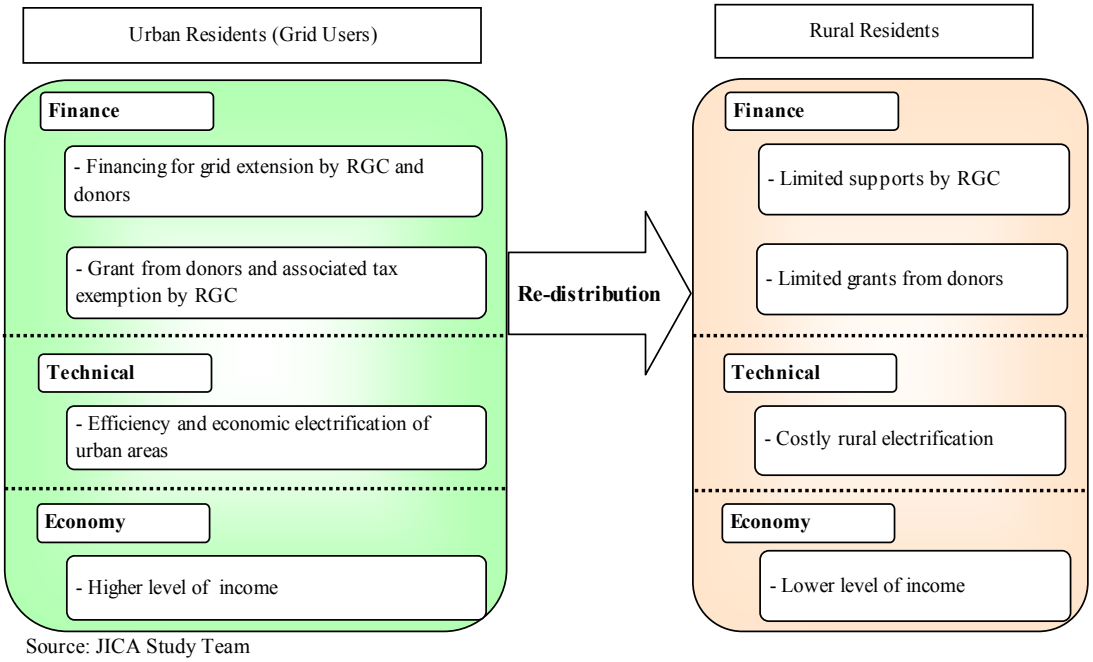
[70] There is an example of a mini-grid with biomass gasification power in Anlong Tamei village in Battambang Province. In three months after the start of operation in February 2005, the television penetration increased to 95% of the total households.

[71] 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.

[72] 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.

tariff of EdC (as a tariff surcharge) and it can be transferred by EdC every month to a proposed CFR[73]. 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 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 realistic 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 25 Background to Need for Cross Subsidy

As shown in Figure 25, 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

[73] 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.

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[74].

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 9 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 Support System for CECs

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:

[74] 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.

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 presented in Attachment-10.

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

The JICA study team recommends that pilot projects[75] be implemented with two micro-hydro mini-grids[76], four biomass mini-grids[77], and one solar BCS. For these candidates, pre-feasibility studies have 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[78]. MIME will be an executing agency and the pilot projects should be implemented on a semi-force account system[79]. 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.

[75] As for prioritization among the electrification plans and selection criteria of Pre-FS candidates, refer to Vol-2 Master Plan, Part 2, Chapter 3.

[76] 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.

[77] 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.

[78] Phase 1 of the Samlout hybrid scheme is with biomass power.

[79] 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.

Source: JICA study team

Figure 26 Power Station Site of the Bu Sra Project

The Bu Sra project has one of the highest ratings for economic efficiency but the people's ability-to-pay is 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 27 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 Phase 1 in an order of priority[80]. Implementation body of the pilot projects should be MIME but after completion the management should be entrusted to the relevant CEC[81]. 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[82]. In addition, these biomass pilots are to 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 28 Tree-lined Street in Kampong Kor Village and Water Supply Barrow

The pilot projects are aimed at the following four factors:[83]

1) To verify applicability of biomass power to rural electrification (setting up and management of CECs, 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[84]; and

[80] The priority is to be in the ability-to-pay and the will to electrify.

[81] 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.

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

[83] Verification themes of the pilot projects are presented in Attachment-12.

[84] 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.

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.

Source: JICA study team

Figure 29 Srae Ta Pan Village

2.3 Mid-term Policy Measures

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 such biomass projects, 40 projects could be implemented every year.

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 10 shows a potential arrangement of the capital costs.[85]

[85] 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.

Table 10 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 10, 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[86], most of the capital needs could be sufficed together with government finance[87].

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).

2.4 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

[86] Actually financial demand will increase through the risks of relending loss.
[87] In order to facilitate the repayment by the government, a grace period of 10 years is desirable.

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 financial support already committed as of 2005[88], that is, proposed tax exemption for renewable energy equipment ($13 million), cross subsidy from the grid users ($40 million[89]), and REF fund which has already been committed ($7.5 million), the village electrification level[90] 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 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%[91] and the household electrification level to the target at 47.0%[92].

[88] 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.

[89] 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.

[90] 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.

[91] Including solar BCS.

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

3. Pre-FS of Promising Projects

Six schemes were selected as Pre-FS candidates for survey and examination. The location of each scheme is shown in the location map at the beginning of this report. Their outlines are presented in Table 11. The project sheets are also attached.[93]

Table 11 Pre-FS of Promising Projects

No.	Province	Scheme	Type	Energy Sources	Phase 1		Phase 1+2	
					HH to be Electrified	Installed Capacity (kW)	HH to be Electrified	Installed Capacity (kW)
1	Battam bang	Samlout	Regional mini-grid	MHP + Biomass	774	120	4,216	582
2	Mondul Kiri	Bu Sra	mini-grid	MHP	936	80	936	80
3	Pursat	Pramaoy	mini-grid	Biomass	146	20	334	45
4	Pursat	Samraong	mini-grid	Biomass	470	64	1,230	180
5	Kratie	Kampong Kor	Regional mini-grid	Biomass	886	120	4,882	640
6	Stung Treng	Srae Ta Pan	BCS	Solar	89	4	89	4
Total	-	-	-	-	3,301	408	11,687	1,531

Source: JICA study team

(1) Feasibility

Economic and financial indicators of the six priority projects are given in Table 12. Of the three micro-hydro schemes studied, the Pramaoy scheme has insufficient river discharge. As a result of a study of alternatives, it is judged that electrification by biomass power has economic advantage over Pramaoy micro-hydro. All the schemes are planned to be operated by a CEC[94]. After pre-FS, pilot projects should be implemented. As for the biomass schemes, the technical issues (environmental standards for liquified waste, etc.) should be verified. In addition, it is a common issue to verify the CEC's ability in operation and maintenance and management of the electrification business, regardless of the source of energy.

(2) Implementation by CEC

For the design and construction of the two micro-hydro projects (Bu Sra and Samlout Phase 2), it is difficult for a CEC to be the main implementing body because of the technical complexity of MHP design and construction. It is recommended that the implementing

[93] In 2005 the JICA study team newly developed village maps showing number of households of each village based on the village data base of Seila 2003 and GIS data. The maps are used for MP study, preparation of location map at the bginning of this report, and electrification planning for the pre-feasibility study. On the other hand, it has been found that social migration exceeds 10% per annum in Samlout and Pramaoy areas along with progress of the demining activities. Accordingly, village socio-economy was analized on the basis of the latest Seila 2004. It is noted there are two figures in the number of households between Seila 2003 and Seila 2004.

[94] Phase 1 of the Samlout and Kampong Kor projects are parts of respective regional mini-grids. In phase 2, an RPC will be in charge of generation and transmission and a CEC will be in charge of distribution and retail. Therefore, it is desirable to select a candidate RPC through public tendering and have its participation from the initial stage of planning.

body be MIME under a semi-force account system. After completion of the construction works, the CEC/RPC (Regional Power Company, a large scale REE to be in charge of power generation and distribution for a wide area of electrification projects) is considered to be capable of undertaking the operation and maintenance of the facilities, and management of the electricity business. For four biomass schemes and one solar BCS scheme, it is considered that a CEC/RPC can be the main implementing body with assistance from DIME and NGOs. However, it is quite important that all the projects should have community workshops towards implementation in the next study and planning stage, to explain and discuss the contents of the project, initial investment costs and tariff levels, etc., in order to obtain sufficient understanding and achieve consensus among the community members.

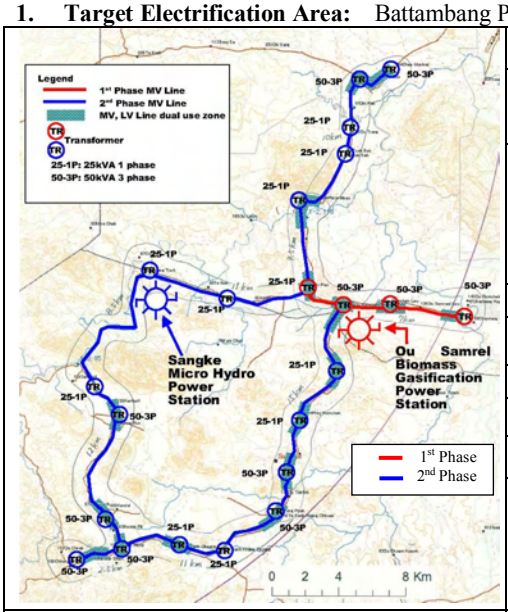
Table 12 Electricity Tariff and Economic and Financial Indicators of Promising Projects

No.	Province	Scheme	Construction Costs ($)	EIRR (%)	Night-time Electricity Tariff ($/kWh)	FIRR (%)
1	Battambang	Samlout	559,000	27.4	0.335	5.6
2	Mondul Kiri	Bu Sra	534,000	12.6	0.160	7.1
3	Pursat	Pramaoy	86,000	33.3	0.400	5.0
4	Pursat	Samraong	219,300	37.3	0.270	4.9
5	Kratie	Kampong Kor	689,100	30.9	0.350	5.2
6	Stung Treng	Srae Ta Pan	31,800	-	0.447	12.2
Total			2,119,200	-	-	-

Source: JICA study team

Samlout Electrification Project (Battambang Province, micro-hydro/Biomass Hybrid)	Pre-FS Summary Sheet	1

1. Target Electrification Area: Battambang Province, Samlout District and parts of Rotanak Mondol District



Target area of Samlout electrification project

＜Communes to be electrified＞	
Rotanak Mondol District	Phlov Meas
	Traeng
Samlout District	Ou Samrel
	Mean Cheay
	Samlout
	Sung
	Ta Sanh

＜Electrification Plan＞

1st Phase (774 households)

BGP* Plant 120 kW (60 kW x 2)

2nd Phase (3,442 households)

MHP* Station: 180 kW
BGP* Plant (Additional): 282 kW (94 kW x 3)

(* BGP: Biomass Gasification Power, MHP: micro-hydro Power)

Streetscape of Sung Commune

Sangke MHP intake site

2. Socio Economic Situation

(1) Major income sources: agricultural products (beans, rice, sesame, bananas), livestock & poultry

(2) Nos. of households (hh), population and others (Note: Household numbers are from Seila 2004)

Target area of electrification	Nos. of hh	Population	TV penetration level (nos.)	Literacy level
Total of 7 communes in 2 districts	7,284	36,556	25.3% (1,845)	87.2%

3. Implementing Capacity and Ability to Pay of CEC

The will for electrification is high in the Ou Samrel Commune. People have experience in community cooperative works such as for road improvement. As the Commune Chief appears to have leadership, the commune is considered to have a good base as a model for implementation by CEC. From the result of a household survey, people spend more than $4 on average for diesel oil lamps and batteries. The TV ownership level is high in a range of 17 to 45%. It is considered that the people have the ability-to-pay for a consumption level of 10 kWh/month, which was a standard level for existing small mini-grids in 2004/2005.

4. Electrification Plan

Electrification will be implemented in two phases as depicted above. From the operation and maintenance (O&M) aspect, it is judged more advantageous to construct a regional mini-grid than have many small mini-grids in every commune. O&M of the power stations and MV lines will be undertaken by a Regional Power Company (RPC). The RPC will be selected through public tendering. The community will establish a CEC, erect distribution lines, get a distribution license from EAC, and distribute to CEC members (customers) by purchasing electricity from the RPC.

Principal Features of Samlout Electrification Project (Note: MV: medium voltage, LV: low voltage)

Phase	Facility	Features	Beneficiary hh
Outlines of Facilities	Energy source	Total capacity: 582 kW	4,216
	Distr. line	MV line: 60.2 km, LV line: 9.5 km, MV&LV dual: 26.3 km	
Construction costs	Phase 1: $559,000 (power plant: $329,000, dist. line: $230,000) Phase 2: $4,769,000 (power plant: $3,657,000, dist. line: $1,112,000) Total: $5,328,000 (power plant: $3,986,000, dist. line: $1,342,000)		

5. Economic and Financial Analyses (Phase 1)

EIRR	Assumed tariff	FIRR	GHG emission effect (in 30 years)
27.4%	$0.335/kWh	5.6%	9,912 t-CO_2

6. Issues toward Implementation

(1) Technical Aspect

1) Public tendering of RPC. One NGO shows interest.

(2) Social and Environmental Aspects

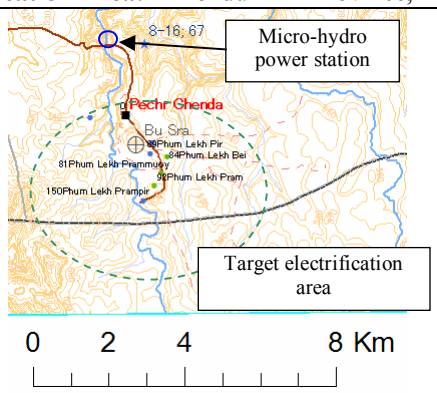
1) A part of the waterway goes through an environment protected area. Scenery and environmental conservation considerations will be required at the design stage.

2) Several parts of the target areas are mine danger zones. Demining works are required.

3) As demining works progress, the population influx (trans-migration) is as high as 10 to 20% per annum (2003-2004). As the number of beneficiary households and influx population are large, community workshops are indispensable to explain and discuss the electrification plan as well as to get confirmation of the service area, demand, and initial equity capital to be raised by each household.

Bu Sra Electrification Project (Mondul Kiri Province, micro-hydro)	Pre-FS Summary Sheet	**2**

1. Target Electrification Area: Mondul Kiri Province, Pecher Chenda District, Bu Sra Commune



Location of target electrification area of Bu Sra Project

Bu Sra Waterfalls (the first cascade, H23m)

2. Socio Economic Situation

(1) Major income sources: agricultural products, livestock & poultry , forestry, seasonal labour

(2) Nos. of households (hh), population and others

Nos. of hh	Population	TV ownership level (nos.)	Literacy Rate	Penetration level of self generator (units)	Battery penetration level (hh)
724	3,395	3.9% (28)	67.7%	3.0% (22)	8.1% (59)

3. Implementing Capacity and Ability to Pay of CEC

For a CEC, design and construction of a micro-hydro power plant is difficult. However, provision of labour force for construction and maintenance works is possible. Setting up and management of a CEC would be led by rich people in the commune. However, through guidance by DIME/NGOs the minority people should participate in setting up the CEC. For the low income people (70 to 80%), it would be required for them to raise the initial equity capital in kind as labour force for construction and maintenance works of the power plant and waterway.

4. Electrification Plan

Energy source	Micro-hydro power, capacity: 80 kW
Features	Catchment area: 197 km^2, gross head: 64.1 m, plant discharge: 0.188 m^3/sec, length of waterway: 330 m, regulating capacity: 3,990 m^3
Distribution lines	MV lines: 9.1 km, LV lines: 10.9 km (8.1 km is a dual use of MV and LV lines)
Construction costs	$534,000 (power plant: $363,000, dist. line: $171,000)

5. Economic and Financial Analyses

EIRR	Assumed tariff (subsidy 50%)	FIRR	GHG emission effect (in 20 years)
12.6%	$0.16/kWh	7.1%	5,900 t-CO_2

6. Issues toward Implementation

(1) Technical Aspects

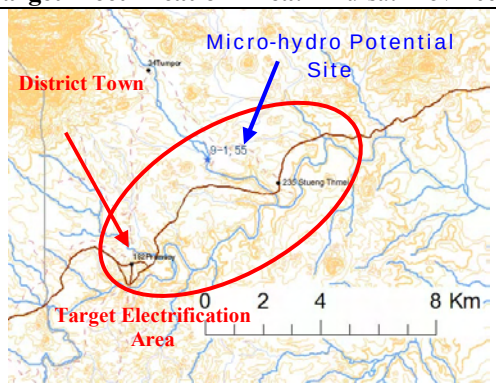
1) In the rainy season, access to the site becomes extremely difficult because of bad road conditions. Improvement of the road for construction is required and for regional development as well.
2) It is desirable to construct a structure having the functions of "flow regulator cum road" with a storage function upstream of the Waterfalls. This bridge will provide the people with safe access even in the flooding season.
3) For local contractors, installation works of penstock pipes on a steep cliff would be difficult.
4) Dry season hydrological characteristics should be further clarified through continuous observation of river water levels and discharges, and installation of rainfall recorders.

(2) Social and Environmental Aspects

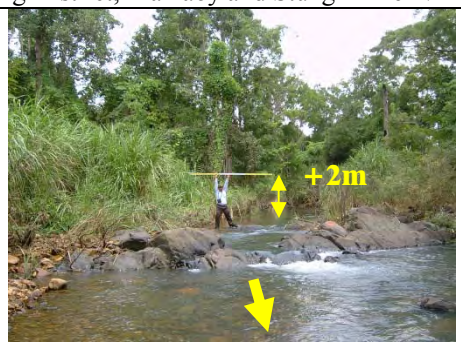
1) Implementation of the project as a pilot will contribute to leveling up the living standard of the minority people (Phnong Tribe).
2) Being located in an environment protected area, scenery and environmental conservation considerations will be required in the design.

Pramaoy Electrification Project (Pursat Province, micro-hydro/ Biomass Hybrid)	Pre-FS Summary Sheet	3

1. Target Electrification Area: Pursat Province, Veal Veng District, Pramaoy and Stung Thmei Villages



Target electrification area of Pramaoy Project



Intake site and flood water level estimated from flood marks

2. Socio Economic Situation

(1) Major income sources: agricultural products (beans, rice, bananas), livestock & poultry

(2) Nos. of households (hh), population and others

Phase	Village	Nos. of hh	Population	Battery Diffusion Level	Literacy Level
1	Pramaoy	229	1,060	70%	73%
1+2	Pramaoy, Stung Thmei	475	2,325		

Note: Household numbers are from Seila 2004

3. Implementing Capacity and Ability to Pay of CEC

Migrants from demining works dominate 60%. Household surveys show average monthly expenditure of more than $100, and people spend more then $4/month for diesel oil lamps and battery lighting. Small scale poor mini-grids (for 60 & 30 households each) exist. TV (color, B&W) ownership level is as high as more than 50%. It is judged that the people have ability-to-pay at a standard consumption level of 10 kWh/month. There is an NGO operating in the area, having experience of training, road construction, and biogass supply for home cooking.

4. Electrification Plan

Based on a study of alternatives, micro-hydro, biomass, and hybrid, it is proposed that a biomass power plant be installed in Phase 1 for electrification of the densely populated district town, Pramaoy. Phase 2 will provide electricity to Stung Thmei Village by extension of another biomass unit. If a significant growth in the daytime demand is foreseen before implementation of Phase 2, it is advised that economic feasibility of micro-hydro be re-examined based on the accumulated measurement records of the dry season discharges.

Features of Pramaoy Electrification Project

Phase	1	1+2
Installed capacity	20 kW	45 kW
Land area for fuel wood plantation 2^{nd}-8^{th} year	4-6 ha	9-14 ha
Distribution lines - MV: Medium Voltage Line - LV: Low Voltage Line	MV 0 km MV+LV 0 km LV 3.0 km	MV 5.0 km MV+LV 2.0 km LV 1.0 km
Construction costs	$86,000	$193,200

5. Economic and Financial Analyses

Phase	EIRR	Assumed tariff	FIRR	GHG emission effect (in 20 years)
1	33.3%	$0.400/kWh	5.0%	1,432 t-CO_2
1+2	34.5%	$0.375/kWh	5.0%	3,302 t-CO_2

6. Issues toward Implementation

(1) Technical Aspects:

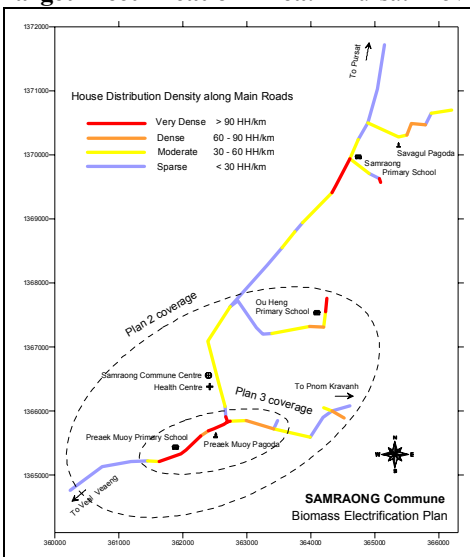
1) Though there is potential for micro-hydro, required discharge was short in the driest month of April 2004 and rainy month in July 2005 as well. Interviews with villagers showed that part of the river stretches dried up in April 2004. Identification of flow duration for the whole year is necessary.

2) Daytime demand should be re-surveyed before Phase 2, and depending on its level it is advisable to re-examine the economic efficiency of micro-hydro and judge whether to install it or not.

(2) Social & Environmental Aspects: Several parts of the target areas are mine danger zones. Demining works are necessary before commencement of survey works for a power house and distribution lines.

Samraong Electrification Project (Pursat Province, Biomass)	Pre-FS Summary Sheet	4

1. Target Electrification Area: Pursat Province, Phnom Kravanh District, Samraong Commune



Target electrification area of Samraong project

Streetscape of Samraong Commune

2. Socio Economic Situation

(1) Major income sources: agriculture, shops, livestock & poultry

(2) Nos. of households (hh), population and others

Phase	Nos. of hh	Population	TV ownership level (nos.)	Literacy level	Battery penetration level
1	504	1,694	6% (30)	86.3%	30%
1+2	1,536	6,910	15% (225)		

3. Implementing Capacity and Ability to Pay of CEC

The main industry is agriculture. An REE once conducted a demand survey. However, there was no certain demand confirmed, and electrification was not realized. People hesitate to invest initial costs but they concluded an ability to cope with a divided payment method as a result of a workshop. Several NGOs have activities.

4. Electrification Plan

Phase	1	1+2
Capacity	64 kWe	180 kWe
Area for fuel wood farming	13 - 22 ha	35 - 57 ha
Distribution line - MV: Medium Voltage Line - LV: Low Voltage Line	MV 0 km MV+LV 0 km LV 2.5 km	MV 0 km MV+LV 11.5 km LV 2.5 km
Construction costs	$219,300	$1,093,000

5. Economic and Financial Analysis

Phase	EIRR	Assumed tariff	FIRR	GHG emission effect (in 30 years)
1	37.3%	$0.270/kWh	4.9%	5,238 t-CO_2
1+2	32.8%	$0.380/kWh	5.9%	13,968 t-CO_2

6. Issues toward Implementation

(1) Technical Aspect: Located at the confluence of three rivers, blessed with water resources even in the dry season and close to the provincial capital. Feasibility should be examined on the possibility of vegetable growing using irrigation pumps, aiming at livelihood betterment and daytime demand creation as well.

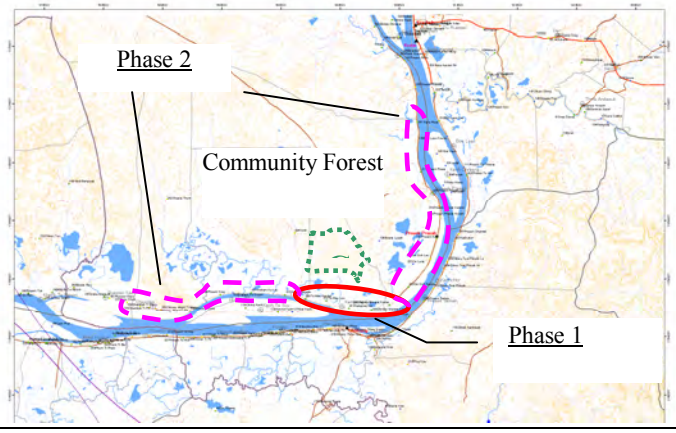
(2) Social and Environmental Aspects:

1) There seems to be no strong community leader.

2) The battery penetration level is low in the center of the commune while high in the suburbs. Social reasons should be examined and reflected in planning.

Kampong Kor Electrification Plan (Kratie Province, Biomass)	Pre-FS Summary Sheet	5

1. Target Electrification Area: Kratie Province, Preaek Prasab District, Kampong Kor Commune etc.



Target electrification area of Kampong Kor Project

Land inside Community Forest (1,461 ha)

2. Socio Economic Situation

(1) Major income sources: agriculture, piggery, retail shops, restaurants, rice-mills, water supply points, ice making

(2) Nos. of households (hh), population and others

Phase	Nos. of hh	Population	TV ownership level (nos.)	Literacy level	Battery penetration level
1	1,107	2,865	41% (454)	96.2%	83%
2	6,102	15,192	35% (2,110)	-	-

3. Implementing Capacity and Ability to Pay of CEC

The target area has NGO's activities for community forestry and has received assistance from many donors in the past. Past education on tree planting management to residents will greatly contribute to sustainable management of fuel tree farming. For setting up of a CEC, the leaderships of the commune chief and monks will play an important role. Coordination with the provincial government can be expected. Battery usage level exceeds 90% and people seem to have sufficient ability-to-pay for electricity at $3 to $4 per month. The will for electrification is exceptionally high and the people plan to raise initial equity capital through monthly saving.

4. Electrification Plan

Phase	1	1+2
Capacity	120 kW	640 kW
Area for fuel wood farming	24-39 ha	132-214 ha
Distribution line - MV: Medium Voltage Line - LV: Low Voltage Line	MV 2.5 km MV+LV 6.0 km LV 2.0 km	MV 13.8 km MV+LV 33.0 km LV 11.0 km
Construction costs	$689,100	$3,275,600

5. Economic and Financial Analyses (Phase 1)

Phase	EIRR	Assumed tariff	FIRR	GHG emission effect (in 30 years)
1	30.9%	$0.350/kWh	5.2%	9,525 t-CO_2
1+2	35.6%	$0.310/kWh	5.2%	52,482 t-CO_2

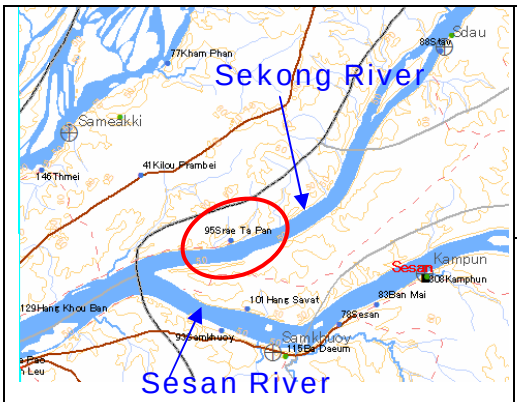
6. Issues toward Implementation

(1) Technical Aspect: Siting of the power plant to land free from inundation, even during the rainy season, is an issue in Phase 1. In Phase 2, new road construction works will be required toward the power plant site beyond a seasonal pond located to the northern part of the commune.

(2) Social and Environmental Aspect: In the community workshop, discussion was held on difficulties in raising the initial equity capital. It was decided to deposit systematically through monthly saving. Further discussion and establishment of measures for raising equity capital is important.

Srae Ta Pan Electrification Project (Stung Treng Province, Solar BCS)	Pre-FS Summary Sheet	6

1. Target Electrification Area: Stung Treng Province, Sesan District, Samkhuoy Commune, Srae Ta Pan Village



Location of Srae Ta Pan Project

A road inside Sra Ta Pan
Sekong River on the right side

Boating place
Go to Stung Treng town on boat for battery charging, 2 hours for return trip.

2. Socio Economic Situation

(1) Major income sources: agriculture, fishery, livestock, forestry

(2) Nos. of households (hh), population and others

Nos. of hh	Popu-lation	Level of literacy	Distance to main road	Hours to main road
95	480	49.8%	2 km	45 minutes

Note: Nos. of household after Seila 2003. The level of battery ownership was 3% at the time of the field survey in July 2005.

3. Implementing Capacity and Ability to Pay of CEC

According to an interview survey by the study team, 65% of the households have monthly expenditures at $50. 88% of the villagers are members of the Lao tribe. Much training will be required for management of the BCS.

4. Electrification Plan

Energy Source	Solar BCS capacity: 4 kWp		Nos. of beneficiaries		89 hh
Principal features	Type of batteries	Capacity	Nos. of batteries to be charged a day		System capacity
	12V battery	50 Ah (30%)	5	18	4 kWp
		70 Ah (50%)	9		
		100 Ah (20%)	4		
	6V battery	5~7 Ah	30		
Costs	$31,800 (BCS equipment: $31,500, shelters & fencing: $300)				

5. Financial Analysis

Assumed tariff	FIRR
$0.447/kWh	12.2%

6. Issues toward Implementation

(1) Technical Aspect:

1) Whether to install a 4 kWp BCS at one location or two 2 kWp small size BCSs, one each at two sub-locations. The capacity can be reduced to a level required to achieve the 25% level of household electrification. Further discussion at the community workshop is necessary.

2) To save costs for installation and operation of the BCS, the possibility of utilizing existing houses and voluntary charging work should be studied and decided through participatory planning.

(2) Social and Environmental Aspect:

1) In setting up the CEC and operation of the BCS, particular consideration will be required for achieving cooperative charging at the BCS between the Lao and Khmer users.

2) People do not have experience of village projects. Enlightenment and monitoring by DIME and initial technical guidance by suppliers are important. NGOs/consultants may also be mobilized as required to support setting up and management of the CEC.

4. Manuals

The following manuals have been prepared through the Study:

1) Manual for MP Updating

Procedures and methods for review and updating of the MP have been prepared for MIME staff. Updating should be done once in every four years, in parallel with the review of the grid extension plans and rural electrification plans. The updated MP would be used as backup data for finance requests to donor agencies. Further, it is recommended that the progress of the MP implementation should be monitored every year in cooperation with Seila.

2) Manual for Preparing Electrification Plans

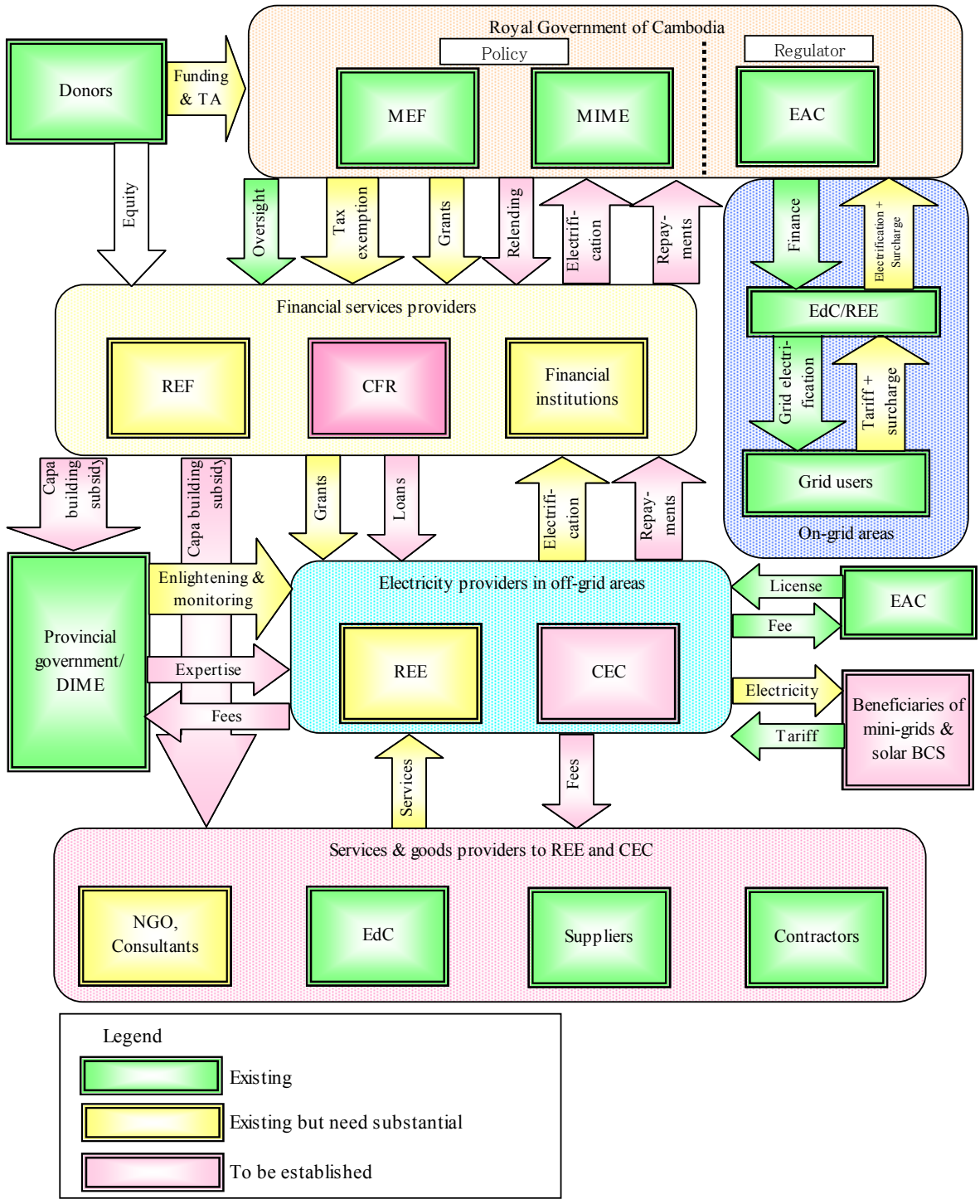
This manual is positioned to elaborate on electrification plans towards implementation. The manual is for DIME and NGOs to master the ways of formulating electrification plans in a target community.

3) Visual Guide

This guide is an illustrated version of the manual above. The manual is for CEC members and covers from setting up of a CEC to formulation of a basic electrification plan (draft).

LIST OF ATTACHMENTS

ATTACHMENT-1 ORGANIZATIONS AND ROLES IN THE POWER SECTOR



Source: JICA Study Team

ATTACHMENT-2 SIGNIFICANT POINTS AND ISSUES IN THE POWER SECTOR

Strong Points	Issues
Government Related Matters	
1) Novel Electricity Law enacted in 2001 ■ Clear role sharing by MIME-EAC-EdC ■ The principle beneficiaries should pay, and open to private enterprise ■ Supply of electrification opportunities	1) Villagers cannot know when the national grid will be extended to their villages, because the grid extension plan has not been approved as a national plan and published officially.
2) Decentralization of Power	2) Settlement of organization relations for provincial government and DIME.
Present Conditions of Rural Electrification	
3) A lot of mature villages with respect to electrification by mini-grid, through the spread of battery lighting. As a result, more than 800,000 households are supposed to be capable of paying $3 to $5/month for an electricity charge with high demand for electrification.	3) Low electrification level
	4) Huge difference of electricity charge between EdC grid and REE mini-grid in rural areas
Funds	
4) MIME is positive about installing renewable energy. Exemption from taxation for imported equipment is under consideration.	5) Lack of funds for MIME/DIME
5) MIME is positive about mutual aid from EdC users and is waiting for a proposal from the JICA study team.	6) In rural areas, cash income is generally low and the ability to pay is limited. In particular, the initial investment is difficult to obtain.
	7) In rural areas, the economic activity, except agriculture, is small. As a result, the power demand is lower than in the city. This causes a high cost.
	8) Because the demand concentrates on lighting at night in the early period of rural electrification, the fixed cost becomes an overburden. This makes the power cost high. As a result, the business profit is low except in the rural cities where both ability to pay and the electricity demand are high. Therefore it is difficult to spread the REE mini-grid into the rural area.
	9) The fund support by REF, which is under establishment with WB assistance, is limited to a grant of 25%. Further, a commercial loan is high interest and short term. Therefore, it is difficult to utilize them in practice.
	10) Solar BCS and biomass power generation are not included in the target of support by REF.
Organizations	
6) A lot of NGOs are active in Cambodia. The villagers can benefit from their support.	11) The lack of engineers for renewable energy development
7) There is a DIME in each province.	12) The funds, technology and staff of REE are limited. ■ REE cannot procure the required money, because the financial system is not mature. ■ The technology for mini-grid electrification has not spread., except by using diesel.

Strong Points	Issues
	■ Engineers have not been trained in appropriate technology, except for solar technology.
	13) The lack of experience of group work due to historical circumstances
Technical Matters	
8) Keep the power source for grid electrification by using cheap power import from Vietnam, Thailand and Laos.	14) Lack of concrete telegraph pole No manufacturer of equipment for micro-hydro power and gasifiers
9) It is possible to electrify the border of Vietnam and Thailand by using direct power import through a distribution line.	15) The micro hydro potential in off-grid areas is limited by the gentle river slope and the remarkable drop in discharge during the dry season.
10) More than 80% of the nation lives in the PAGE. This makes effective electrification possible.	16) The potential of wind power is low and limited to a partial corridor of wind.
11) There is micro hydro potential in the east and south west mountain areas.	
12) Biomass is abundant due to there being enough rainfall, sunshine and fertile land.	
13) The solar potential is abundant.	
Others	
14) The village database of NIS and Seila is available.	17) There is no available renewable system for the information of villages. The latest electrification conditions using batteries has not been understood because the battery lighting was spread quickly after the national census in 1998.
15) A GIS database is available (including the topographic maps at 1:100,000 scale, land utilization maps, routes of existing distribution lines and Village electrification plans)	

ATTACHMENT-3 ELECTRIFICATION PLAN BY GRID EXTENSION

(1) The National Target of Household Electrification Ratio and Required Rate of Increase for its Achievement

The Cambodian Government aims to electrify 70% of the rural households with grid quality electricity by year 2030. However, the present electricity supply by grids is limited to the capital, provincial towns and major areas covered by EdC and private power providers. The electrification ratio of the country is still at a low level, 18.5% at present. The required annual averaged increase rate to achieve the 70% of electrification target in 2030 from this low level is shown in Table A-1.

Table A-1 Required Increase Rates for Achieving Electrification Targets

Provider group	Household electrification ratio (%)			Average increase rate (%)	
	2004	2020	2030	(1)	(2)
1. EdC only	8.4	31.0	70	8.4	10.6
2. EdC + Licensees of EAC	10.8	34.1	70	7.5	9.6
3. EdC + Licensees of EAC + Others	18.5	41.9	70	5.3	7.4

Note (1) : The required rate of annual average increase of numbers of electrified households on the assumption that the population increase rate is 0%
(2) : The required rate of annual average increase of numbers of electrified households on the assumption that the population increase rate is 2% per annum

The average rate of increase of electrification ratio for the past 6 years in the area where the electricity is supplied by EdC was 11.4% (in the case including the areas transferred from DIME, 15%). Therefore the target seems easy to achieve, because the required rate of increase shown in Table A-1 is lower than that actual past increase rate. However, the past area electrified by EdC is limited to the populated urban areas. Further, it is the result of power reinforcement and grid expansion with the aid of donors including Japan. A further effort will be required to promote the rural electrification.

(2) Potential Area of Grid Extension （PAGE）

To promote the improvement of the above low electrification ratio, both the HV grid extension to all provinces and the MV grid extension to major cities and high demand areas in each province are required urgently. The potential area for MV grid extension was defined as the area out to 40km from the grid substation (GS) in this master plan taking account of the future demand increase, though the area 50km to 60km from the GS is technically possible for electrification in the low demand areas. The value of 40km that was applied in the various plans in the Cambodian energy sector was judged as appropriate both technically and economically.

The grid extension plan in the country is still at the initial stage. It is appropriate to construct a GS at each provincial town for which the electricity demand is highest in the province in order to improve the electrification in the area by extending the grid nationwide.

The areas in the circles with a radius of 40km whose centers are in all the 24 provincial towns are where it is technically possible to provide electrification by the extension of the MV line. These areas are called the Potential Area of Grid Extension (PAGE) in this master plan and are given in Figure A-1.

More than 80% of villages and households in the country are located in the PAGE. Therefore, rural electrification by grid extension is effectively very feasible in Cambodia if the required funds could be procured for grid extension.

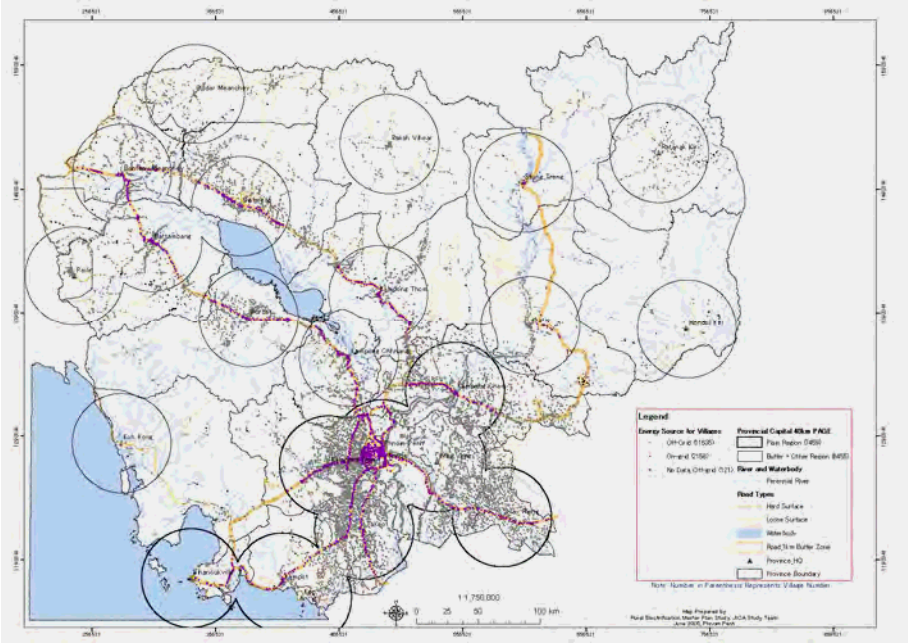
(3) Off-Grid Area

The electrification by grid extension (called Grid Electrification) and the electrification by isolated mini-grids and/or BCS in off-grid areas (called Off-grid Electrification) were set as the two main features for rural electrification in this master plan.

It should be noted that the whole areas of PAGE were not committed to be electrified by grid

electrification although it was the target area for EdC to study the grid extension in the middle and long term. In cases where electricity is supplied to the customers by LV lines（400/230V） and step down transformers through extension of the 22kV line from the GS, the supply area is limited to within 1km from the transformer due to the voltage drop, even in the low demand areas. Namely, the areas within 1km along 22kV lines are the target areas for the grid electrification. To electrify the area further than 1km from the 22kV line, it is necessary to extend another 22kV line from the existing line. In other words, the on-grid areas and the off-grid areas are intermixed in the PAGE and the proportion of the on-grid and off-grid areas is changed time to time in company with the extension of the 22kV line in the PAGE.

Because of the above, the off-grid area that is the target of this master plan includes the areas in the PAGE where the 22kV line has not been installed yet and all the areas outside of the PAGE. In particular, the off-grid areas in the PAGE should not remain as target areas by EdC grid electrification but be opened up to REE and CEC. An equal opportunity for self-electrification should be given to the villages with low priority for grid electrification in the country.



Source: JICA Study Team

Figure A-1 Potential Area of Grid Extension (PAGE)

(4) Extension Plan for National Grid

The extension of the power transmission system to the outside areas of Phnom Penh has not been undertaken to promote rural electrification and increase power demand, even though the country has a large latent electricity demand, because of the shortage of power supply capability. Furthermore, the shortage of power supply capability and high electricity tariff have combined to suppress the connection of large parts of medium and large scale industries and hotels categorized as big customers to the grid and have encouraged them to operate their own generating plants for their use.

The past grid extension plan had been formulated for linking new power development and not for promoting rural electrification. However, these studies are acceptable, because any grid extension plan has no meaning without certain power supply sources.

Under this situation, the following cross border transmission line projects are on-going to import electricity from neighbouring countries. Energy prices for electricity imported through these transmission lines will be around US¢7.0/kW level and imported energy will eliminate the above-mentioned bottle-necks (shortage of supply capability and high electricity tariff) for grid extension in the country.

1) Vietnam – Phnom Penh 220kV 2CCT transmission project: The design work by

consultants was commenced in 2005. The capacity of imported power will be 80 MW in the initial stage and be increased to the 200 MW level.

2) Thailand – West of Cambodia 115 kV 1CCT transmission project: The construction work commenced in December of 2005 and is scheduled to be completed at the end of 2007. Imported power capacity is limited to the power demand of Banteay Meanchey, Battambang and Siem Reap areas, but import of up to around 80 MW is technically possible.

3) Laos – Northeast Cambodia 115 kV 1CCT transmission project: This project is planned under the Phase-1 GMS project. More detailed study (F/S) is on-going (2005).

In this master plan, the extension plan has been made referring to the EdC extension plan, with time slices of 2008, 2012, 2016 and 2020 taking account of decisions relating to the detailed scope of works, preparation of documents for procurement, tendering, construction, etc. The result of the study is given in Figure A-2. In this study, however, the extension of the transmission system to Koh Kong and Pailin provinces has not been considered in the plan up to 2020 because the provincial town areas have been electrified by electricity imported from Thailand by private power providers and the demand is still at a low level.

(5) Extension of the Sub-Transmission Grid

In the master plan study, the sub-transmission grid (22 kV) is planned for extension from the GS in the PAGE in the following three stages for integration with isolated mini-grids operated by power providers and for promotion of rural electrification.

The First Stage:

22 kV lines will be extended with priority ① along the national roads with a single digit (except for the roads in the sparse areas of villages) and ② along roads reaching to the district centers in the PAGE, taking account of its maintenance requirements. It is recommended that the extension works of this stage be implemented under the same project as for the extension of the HV grid, including design, procurement of materials and construction.

The Second Stage:

Non-electrified villages and communities along the MV lines extended from the GS under the first stage will be electrified with priority for effective use of the existing power transmission facilities. The MV lines will also be further extended to the other areas having relatively high density of population. The sub-transmission extension project under this stage shall be continued to cover electrification of all villages in the PAGE.

The Third Stage:

This stage will be applied to the provinces in case some district centers are outside 40 km from the GS and/or the degrading effect of voltage drop at the end of the MV line constructed under the previous stage is getting more and more obvious. A combination of new extensions of the HV system, new construction of GSs and extension of 22 kV lines, will be utilised for that purpose.

Detailed study for the first stage has been completed and its results are given in Table A-2 and Figure A-3.

Table A-2 Sub-transmission Grid Extension Plan

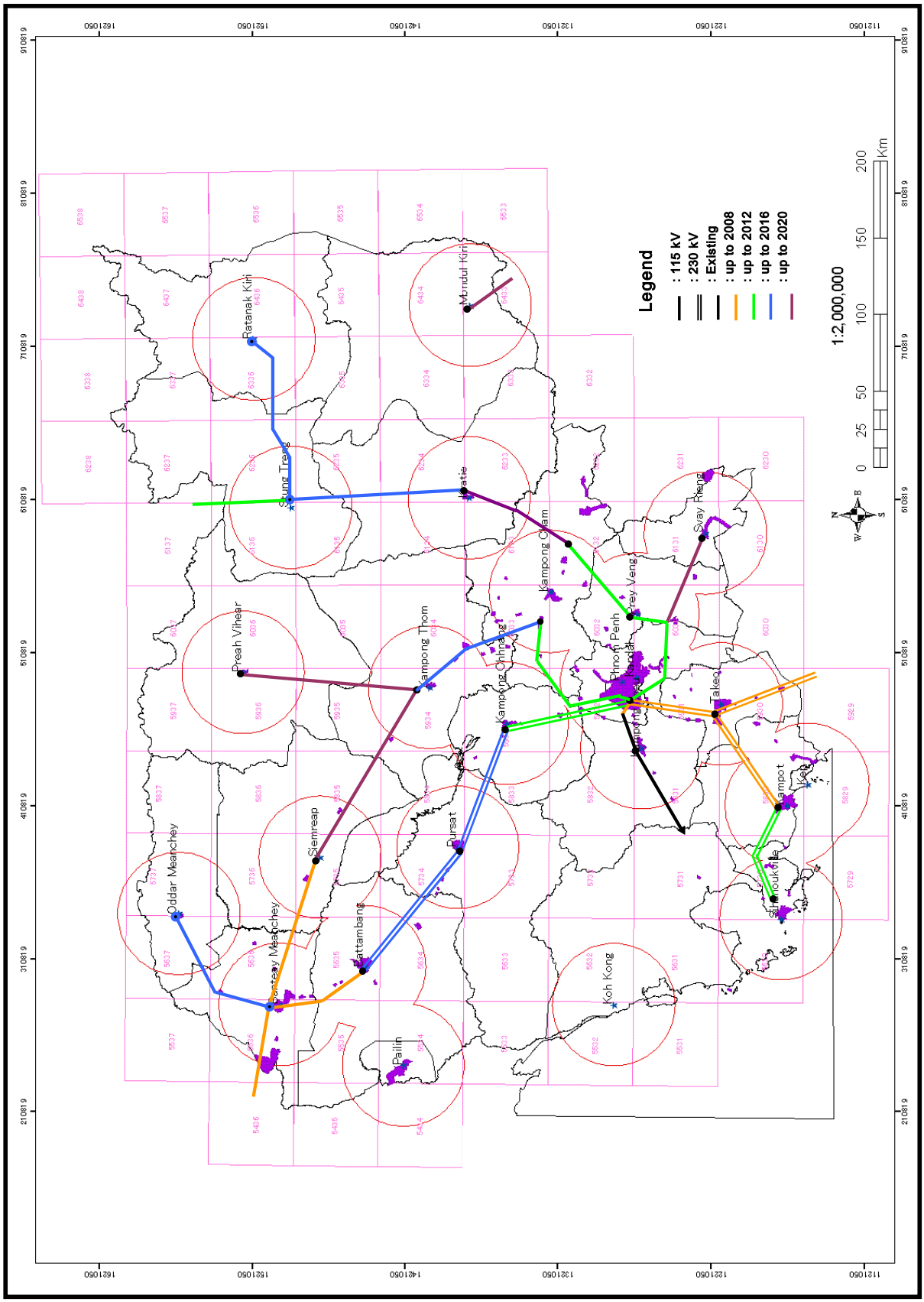
Nos. to be integrated with the National Grid	Up to 2008	Up to 2012	Up to 2016	Up to 2020	Total
Provinces	8	6	5	3	22
District Centers	40	30	21	11	102
Present Licensees (2004)	43	25	8	1	77
22 kV Feeders	28	16	13	7	64
22kVLine Length (km)	1,127	755	498	272	2,652

Source: JICA Study Team

(6) Power Demand Forecast for On-Grid

The power demand of the areas supplied by the national grid was determined on the basis of the

actual demand in 2004 in accordance with the transmission extension plan formulated above (3). The actual demand of grid-quality electricity in 2004 has been considered in three groups, i.e. 1) demand supplied by EdC, 2) demand supplied by REE licensed by EAC and 3) demand supplied by non-licensed REE. The demand supplied by non-licensed REE has been estimated on the basis of the questionnaire to DIME by the Team.



Source: JICA Study Team

Figure A-1 Transmission Line Extension Plan for Rural Electrification (Draft)

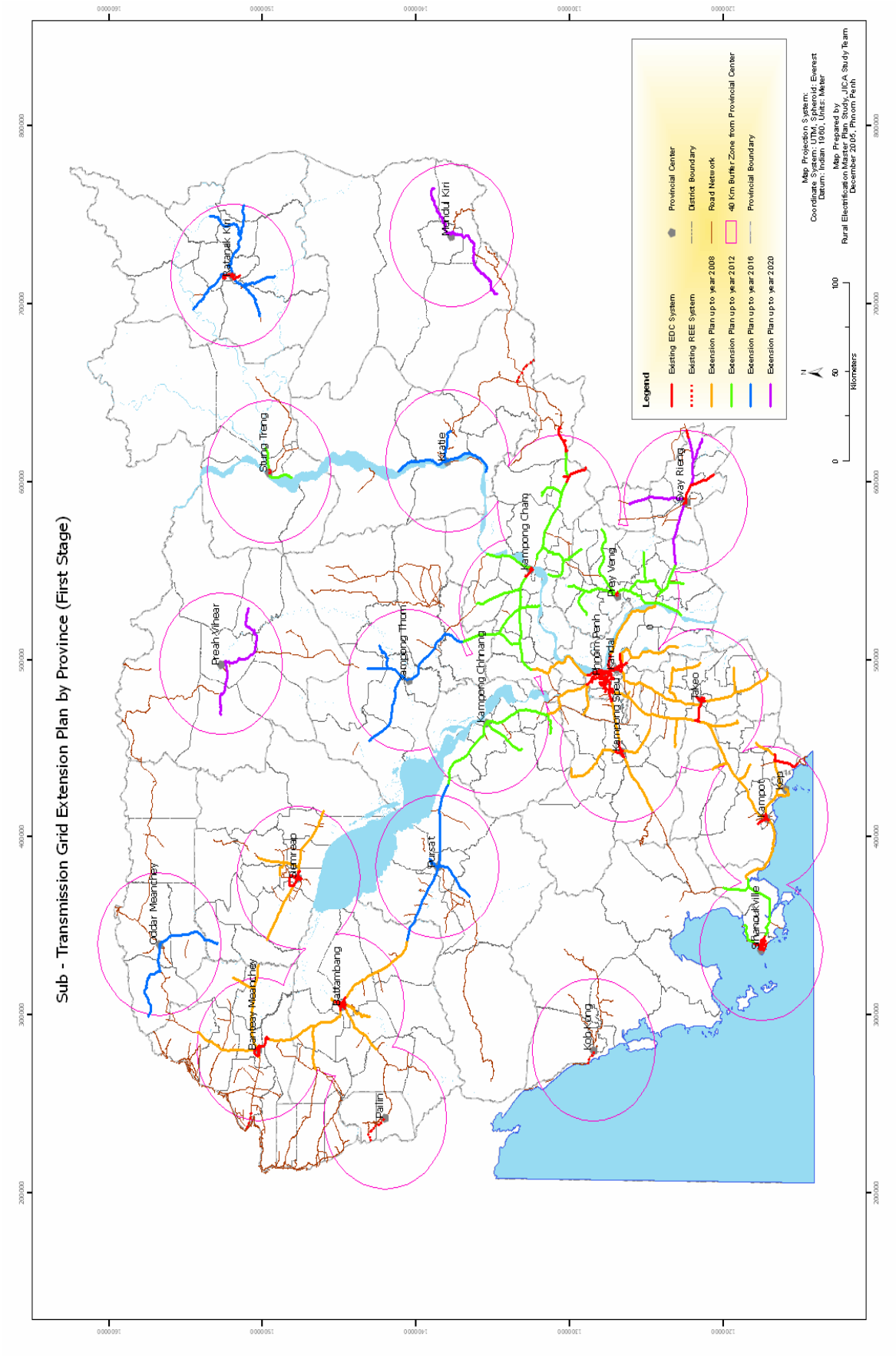


Figure A-2 Extension Plan of 22 kV Transmission Lines (Draft)

Table A-3 Summary of Demand Forecasts for Cambodian National Grid (2004-2020)

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Averaged Increase Rate
I. Number of Domestic Customers by Province																			
Up to 2008	Phnom Penh/Kandal	157,438	169,201	181,891	195,533	211,671	228,450	245,752	263,510	281,657	300,125	318,850	337,770	356,829	375,977	395,173	414,380	433,570	6.54
	Kampong Speu	5,295	5,700	6,127	6,587	7,507	8,557	9,748	11,095	12,617	14,332	16,263	18,431	20,859	23,574	26,598	29,959	33,682	12.26
	Banteay Meanchey	44,808	48,280	51,901	57,010	62,417	68,114	74,087	80,317	86,786	93,473	100,356	107,414	114,624	121,967	129,423	136,975	144,608	7.60
	Battambang	17,228	18,516	19,904	23,653	26,659	29,998	33,696	37,778	42,268	47,187	52,555	58,388	64,699	71,494	78,775	86,538	94,772	11.24
	Siem Reap	12,650	13,594	14,614	16,575	18,780	21,248	24,001	27,065	30,464	34,220	38,357	42,896	47,855	53,249	59,091	65,386	72,139	11.49
	Takeo	10,108	10,872	11,687	12,564	14,171	15,971	17,980	20,218	22,703	25,457	28,500	31,852	35,533	39,559	43,948	48,712	53,861	11.02
	Kampot	7,767	8,358	8,985	9,658	10,901	12,297	13,856	15,592	17,521	19,659	22,022	24,623	27,479	30,602	34,004	37,694	41,680	11.07
Up to 2012	Stung Treng	2,376	2,554	2,746	2,952	3,173	3,411	3,824	4,278	4,774	5,312	5,894	6,521	7,192	7,908	8,667	9,467	10,308	9.61
	Sihanoukville	9,556	10,272	11,042	11,870	12,761	13,718	15,160	16,694	18,323	20,045	21,857	23,754	25,732	27,786	29,911	32,101	34,352	8.33
	Kampong Chhnang	6,285	6,758	7,265	7,810	8,395	9,025	9,702	10,429	11,848	13,440	15,224	17,217	19,437	21,902	24,629	27,636	30,939	10.47
	Kampong Cham	31,624	33,973	36,521	39,260	42,204	45,369	48,772	52,430	58,687	65,582	73,143	81,406	90,399	100,145	110,661	121,956	134,027	9.45
	Prey Veng	10,337	11,122	11,957	12,853	13,817	14,854	15,968	17,165	19,251	21,586	24,176	27,042	30,205	33,685	37,502	41,677	46,226	9.81
Up to 2016	Pursat	7,325	7,868	8,459	9,093	9,775	10,508	11,296	12,143	13,054	14,033	15,739	17,625	19,696	21,961	24,428	27,103	29,991	9.21
	Kampong Thom	7,956	8,559	9,201	9,891	10,633	11,430	12,287	13,209	14,200	15,265	17,217	19,390	21,803	24,474	27,421	30,660	34,207	9.54
	Oddar Meanchey	949	911	979	1,052	1,131	1,216	1,307	1,405	1,511	1,624	1,860	2,126	2,429	2,773	3,162	3,602	4,098	9.57
	Ratanakiri	2,141	2,301	2,473	2,659	2,858	3,072	3,303	3,551	3,817	4,103	4,411	4,742	5,359	6,045	6,803	7,638	8,553	9.04
	Kratie	2,758	2,967	3,189	3,428	3,686	3,962	4,259	4,579	4,922	5,291	5,688	6,114	6,954	7,896	8,955	10,140	11,463	9.31
Up to 2020	Svay Rieng	6,256	6,730	7,234	7,777	8,360	8,987	9,661	10,386	11,165	12,002	12,902	13,870	14,910	16,029	17,909	19,991	22,274	8.26
	Previhear	750	829	891	958	1,030	1,107	1,190	1,279	1,375	1,478	1,589	1,708	1,836	1,974	2,257	2,577	2,941	8.92
	Mondolkiri	430	462	497	534	574	617	664	713	767	824	886	953	1,024	1,101	1,257	1,433	1,631	8.69
Whole Country	Total	344,037	369,825	397,562	431,717	470,503	511,912	556,513	603,837	657,709	715,039	777,489	843,842	914,855	990,101	1,070,574	1,155,625	1,245,322	8.37
	New Customers	–	25,788	27,737	34,155	38,787	41,409	44,601	47,324	53,872	57,330	62,451	66,353	71,013	75,246	80,473	85,051	89,697	
	Total Households (1000)	2,290.3	2,335.9	2,382.6	2,430.3	2,478.9	2,528.7	2,579.5	2,631.4	2,684.4	2,738.6	2,793.9	2,850.4	2,908.2	2,967.2	3,027.6	3,089.2	3,152.2	2.02
	Electrification Ratio (%)	15.02	15.83	16.69	17.76	18.98	20.24	21.57	22.95	24.50	26.11	27.83	29.60	31.46	33.37	35.36	37.41	39.51	6.23
II. Sold Energy for Domestic Customers on Grid by Province (MWh)																			
Up to 2008	Phnom Penh/Kandal	257,185	276,474	297,209	319,500	345,870	373,287	401,559	430,575	460,228	490,404	521,001	551,916	583,059	614,346	645,713	677,097	708,453	6.54
	Kampong Speu	1,251	1,345	1,446	1,554	1,772	2,019	2,301	2,618	2,978	3,382	3,838	4,350	4,923	5,563	6,277	7,070	7,949	12.25
	Banteay Meanchey				7,183	7,865	8,582	9,335	10,120	10,935	11,778	12,645	13,534	14,443	15,368	16,307	17,259	18,221	7.25
	Battambang				17,101	19,274	21,689	24,362	27,313	30,560	34,116	37,997	42,215	46,777	51,690	56,954	62,567	68,520	11.15
	Siem Reap				21,266	24,095	27,261	30,793	34,724	39,085	43,904	49,212	55,036	61,398	68,318	75,814	83,890	92,554	11.87
	Takeo					3,925	4,424	4,980	5,600	6,289	7,052	7,895	8,823	9,843	10,958	12,174	13,493	14,919	11.77
	Kampot					3,957	4,464	5,030	5,660	6,360	7,136	7,994	8,938	9,975	11,109	12,343	13,683	15,130	11.54
Up to 2012	Stung Treng							1,147	1,283	1,432	1,594	1,768	1,956	2,158	2,372	2,600	2,840	3,092	10.42
	Sihanoukville							17,918	20,767	22,794	24,936	27,190	29,550	32,011	34,566	37,209	39,934	42,734	9.08
	Kampong Chhnang									5,557	6,303	7,140	8,075	9,116	10,272	11,551	12,961	14,510	12.75
	Kampong Cham									22,184	24,790	27,648	30,771	34,171	37,855	41,830	46,099	50,662	10.87
	Prey Veng									7,007	7,857	8,800	9,843	10,995	12,261	13,651	15,170	16,826	11.57
Up to 2016	Pursat											6,296	7,050	7,878	8,784	9,771	10,841	11,996	11.34
	Kampong Thom											5,492	6,185	6,955	7,807	8,747	9,781	10,912	12.12
	Oddar Meanchey											744	850	972	1,109	1,265	1,441	1,639	14.07
	Ratanakiri													1,543	1,741	1,959	2,200	2,463	12.40
	Kratie													4,096	4,651	5,274	5,972	6,752	13.31
Up to 2020	Svay Rieng															11,963	13,354	14,879	11.52
	Previhear															1,508	1,721	1,965	14.15
	Mondolkiri															377	430	489	13.91
III Total Energy Demand and Peak Demand																			
Domestic Energy (MWh)		258,436	277,819	298,655	366,605	406,758	441,727	497,425	538,663	615,408	663,253	725,660	779,093	840,311	898,772	973,288	1,037,804	1,104,667	9.50
Other Energy Demand (MWh)		294,617	323,659	355,400	445,425	504,380	558,784	641,679	708,341	824,647	905,340	1,008,667	1,102,416	1,210,048	1,316,700	1,450,199	1,572,274	1,701,188	11.58
Total Energy Demand (MWh)		553,054	601,478	654,055	812,029	911,138	1,000,511	1,139,104	1,247,004	1,440,054	1,568,593	1,734,327	1,881,509	2,050,358	2,215,472	2,423,488	2,610,078	2,805,855	10.68
Sent Out Energy (MWh)		655,277	710,547	770,383	953,646	1,066,907	1,168,139	1,326,082	1,447,480	1,666,730	1,810,263	1,995,774	2,158,932	2,345,948	2,527,635	2,757,096	2,960,951	3,174,044	10.36
Peak Demand (MW)		120.7	130.8	141.8	175.6	196.4	215.1	244.2	266.5	306.9	333.3	367.5	397.5	431.9	465.4	507.6	545.2	584.4	10.36

ATTACHMENT-4 SUMMARY OF COMMUNITY WORKSHOPS

1. Objectives

Community workshops were held in ten communes in six pre-feasibility sites. The objectives of the workshops were as follows:

① to verify the feasibility of an electrification project using a community electrification cooperative (CEC) approach, and

② to clarify problems, issues and measures, and then give feedback by designing supporting mechanisms for CECs.

2. Outline

The outlines of the workshops are shown in the table below:

Site	Province	No. of Participants	Type of Electrification
Srae Ta Pan	Stung Treng	29	Solar BCS
Kampong Kor	Kratie	46	Biomass
Bu Sra	Mondul Kiri	51	MHP
Samlout (Ou Samrel)	Battambang	37	Hybrid
Samlout (Mean Chey)		116	
Samlout (Samlout)		27	
Samlout (Sung)		17	
Samlout (Tasanh)		46	
Pramaoy	Pursat	27	MHP/hybrid
Samraong	Pursat	28	Biomass

3. Solar BCS Scheme

(1) Preparedness for Electrification

- Ability to pay is a key point in judging the feasibility because it is generally in a poorer part of the Srae Ta Pan area.
- The criteria of the ability to pay are 1) ability to buy a 12V battery, 2) capability to prepare facilities (land and building) including the labor force, 3) ability to pay a charging fee.

(2) Accessibility

- When considering the project service area and the location of facilities, accessibility to the BCS is an important point to be considered because people have to bring a heavy battery to the BCS.
- It is necessary to compare accessibility of a solar BCS with commercial diesel BCSs nearby.
- A collection and delivery system can be considered if it is found that there is difficulty with the access to the BCS. Such a system is operated with the existing BCSs corresponding to the demand for collection and delivery. The charge for collection and delivery should not be included in the charging fee but should be left to the demand and market mechanism.

(3) Others

- It is necessary to consider the responsibility in cases of damaged or stolen BCSs. In Cambodia, however, the solar lighting system installed at isolated bridges is maintained without damage or theft. It is said that no-one steals them if they are installed with a ceremony including invited governmental high ranking officers. Therefore it is considered that there is a risk of damage and theft.

(4) Feasibility in Srae Ta Pan

- Ability to pay as a prerequisit for electrification is low. It is difficult for most of the participants (23 participants out of 25) to buy a 12V battery (approx. $30) and to pay $5 of the cost for building construction. It seems, however, that the cost for building construction is not a problem. A building for a BCS is not necessary because the number of daily battery charges is about eight if the target number is 40 households as one half of the total.
- Feasibility would be low in terms of accessibility if the BCS was to be installed at the place planned originally. The village is divided into two communities and it takes about 30 minutes to get to the planned BCS location in between the two community centers. It seems that there is not a lot of merit for the BCS in terms of accessibility because the major means of transportation on land is by walking.

There is little communication and exchange between the communities and they may charge their batteries in Stung Treng because they have a stronger connection with Stung Treng by boat. It is necessary that the BCS location is divided for the two communities or that a collection and delivery system, as a small business, be established.

- In terms of operation by the CEC, a friendly and cooperative operation is a concern because there is little sense of collaboration between communities and there is a distance between them topographically. In this connection, it is advisable that the BCS be divided for the two communities.
- It is necessary for the community members to consider whether 1) to install two smaller BCSs or 2) to introduce a collection and delivery system.
- Human resources for an operator and an accountant are available but training is essential for them.
- It is a concern that every community member may not be able to bear the cost of the building and fence equally. However, it is possible to prepare a building and fence because a rich participant expressed the fact that he can bear the cost if some members cannot afford it.
- It is impossible for most of the participants to bear a $5 charge for the building construction. It was assumed that a new building is to be built. However, it is possible to use an existing building such as the house of the operator.

(5) Policy Basis

<*Social Electrification* = Electric Welfare>

- It is desirable that equipment is provided from a grant, considering it as *Social Electrification* for achieving the village electrification target.
- Users should buy the battery and pay a charging fee at a price to be set with reference to surrounding market prices because the unit charging cost of solar BCSs is the most expensive. The lease charge should be collected and kept in a reserve as a supporting fund.
- Power by BCS battery is impossible to use as a power source for items such pumps because the power can be used only for lighting, TV and so on. Therefore it is difficult to expect economic benefit frrom investment in a BCS installation.
- The financial benefit of a BCS installation is an educational benefit that enables children to study at night, and an enlightening benefit to enhance readiness for electrification so that participants can easily step up to mini-grid electrification.

<*Social Electrification*>

- The beneficiaries of a BCS scheme as a social development project are divided into two groups, which are the people who can purchase a 12V battery, and those who can not, in terms of ability to pay.
- There is no benefit in the installation of a BCS in terms of the rural electrification objective if they cannot buy a 12V battery. A social development project aiming at promotion of electric home lighting with a 12V battery may be more of a priority than a direct electrification project for the people who cannot buy a 12V battery. However, installation of a BCS can be considered as a social development project because most of those people have a 6V battery which is used for their livelihood. It is possible that revenue from BCS charging, which is a surplus after paying the lease charge, salary for the operator and necessity charges such as repair services, can be used for micro-credit for the purpose of buying a 12V battery.
- The electrification objective can be achieved by those beneficiaries whose ability to pay is low but can use the BCS for charging their 6V battery, and then are able to buy a 12V battery by using micro-credit.
- Therefore, BCS installation for this level of people can be considered *Social Electrification* as one of the social development projects utilizing micro-credit.

4. Mini-Grid Scheme

(1) Readiness for Electrification

i) Ability to provide equity capital

- Providing equity is a large issue. Only three out of nine communes expressed the ability to be able to provide $50 as equity capital, which is assumed to be 10% of the total initial cost per household. It is almost impossible for them to provide 25% of the cost, which is expected in the REF scheme. Therefore, long-term and low interest rate loans are essential.
- Bearing the minimum equity capital is essential. In this connection, $50, which is equivalent to the amount for connection to the house and to provide interior wiring, is a relevant cost.

- People are not used to saving cash in the rural area. It is difficult for them to provide for a monthly kerosene cost though they can produce a daily amount. Some REE collect a power charge every two weeks. This is an idea for such a situation.
- It is difficult for some people to pay equity in advance.
- It seems providing equity is not necessarily difficult if they understand and are confident in the project through enlightenment and can share the goal and decision among community members.
- Saving activity for the purpose of providing equity is important. It seems effective for equity preparation to collaborate with other livelihood projects, such as micro-credit and animal raising, supported by NGOs.

ii) Electrical Literacy (knowledge of electricity, use experience, degree of use)

- It is advisable for the areas where the possession ratio of 12V batteries is low (Bu Sra, Samraong) that battery electrification in each household is prioritized.
- It is necessary to confirm the possession ratio of 12V batteries in an area where it is planned to provide service by mini-grid. Even if the ratio in the whole commune is low, a mini-grid may be planned in terms of electrical literacy if the ratio in the service area, such as covering the households along a main street, is high and the ratio in the other surrounding areas is low.
- In such a situation, it is advisable for the CEC to encourage installing a BCS in the mini-grid for the people in the surrounding area. Financial support should cover the cost of such BCS equipment to be powered by the mini-grids. BCS installation will ensure fairness and enhance battery electrification. This idea supports the policy basis of the MP. In addition, BCS installation creates daytime demand for the mini-grid. As a result, BCS installation can combine the effectiveness of lower generation cost and BCS service enhancement.

iii) Demand assessment

- Demand assessment is a key point which makes a project successful or not. Underestimation of the demand causes lack of power while an overestimate of the demand causes lack of revenue and increase in tariff. Increase of power consumption and growth by new members joining are expected in the future.
- It is important to encourage daytime demand, such as from BCSs, rice mills, water pumps, irrigation pumps and small industry, for income generation. Consequently the approach aiming at the synergy effect of the electrification and social development projects is effective.

iv) Ability to pay monthly charge

- It seems to be not so difficult to pay monthly charges.
- Users of 12V batteries spend $3 per month at least, which is the sum of the charging fee and the average battery cost on a monthly basis. As a battery costs about $30 and its life duration is 1.5-2 years, then it costs $1.50 per month. In addition, most of these households use kerosene/diesel lamps or candles together with a battery. It is considered that they have enough ability to pay the monthly charge for mini-grids if newly introduced into their villages.
- They expressed that they have repayment ability once they have a long-term and low interest rate loan. In other words, such a soft loan is very necessary for them.
- Also, enlightenment and education on how to use mini-grids (such as reminding users not to leave electric appliances switched on when not in use) are required. Otherwise they would be billed with an expensive tariff if they consume too much electricity, unlike the battery situation with which they cannot consume beyond the battery capacity without paying a charging fee.
- Most of the participants in the workshops chose a consumption model of Riel 18,200 ($4.50) per month (out of the five consumption and monthly models presented) that uses two fluorescent lights (20W) and a black and white TV (40W) or a fan (40W) for four hours a day. If it is considered to represent their ability to pay a monthly charge, they can repay the initial investment costs through a monthly electricity tariff or they can repay soft loans if provided.

(2) Human Resources

- It seems that candidate operators are available in most of the communes visited. It was confirmed that the operators are available in all the 10 communes where workshops were held. Their present occupation is repairing motorbikes and cars. There are several people who have their own generators and tractors in one commune.

- However, training is necessary for operators to cope with damage, while no specific issue is foreseen in daily operation.
- Periodical patrol inspection tours by external facilitators/experts is important to secure sustainability of the electricity business. Such inspection costs should be treated as part of the implementation costs and should be subject to financial support by supporting agencies (REF and CFR).
- It is necessary for the operator candidates to coordinate with their current jobs. Many of them have farm land as well. It seems possible to solve the issue of work arrangements by using their family members or help from other CEC members with their agricultural work in the busy season.
- There are many candidate accountants everywhere. They are school teachers, business persons, students, commune office staff, and so on.
- They, however, do not know how to calculate the monthly electricity tariffs of each member. External support is necessary to train on such technical work.
- It is desirable that an accounting system is developed for every accountant to work easily and accurately.
- SMEC, an NGO, developed an accounting software package and can provide it to a community. It seems, however, that only a few communities have PCs in commune offices. Therefore, use of such software would be limited. It is expected that some communities will have PCs within a few years after installation of a mini-grid.

(3) Composition of CEC members and project service area

- It is an issue to decide a service area, that is, which villages, sub-villages or which households should be electrified by mini-grid.
- There are various types of household distribution with a community. In Kampong Kor, houses are located continuously along a main road. In Bu Sra, houses are located not only along the main road but also along small branch roads. In Pramaoy commune, Stung Thmei village is divided into five sub-villages and there are long distances between them.
- It is important to ensure fairness, social equity and a transparent process of decision making in a community.
- Therefore, objective indicators are necessary, such as 1) technical standard (service width = distance of branch line from main distribution lines = a maximum of 1 km from a technical viewpoint), ii) financial criteria (about $600 per household including tax and indirect costs), where customer density = service population per unit distance of branch line), iii) recommended scale (more than 200 households preferable with biomass gasification power), iv) minimum ratio of participants (number of participants of CEC members out of the total population in the service area to be more than 50%) and so on.
- There are 30 Khmer households out of about 700 households in the Bu Sra commune and the others are the Phnong people (minority group). In such an area there is a possibility that 30 Khmer households who stay in the center of the commune might establish a CEC, and then it would cause conflict between the two groups. Such conflicts should be avoided.
- Therefore a CEC service area should be decided as an area that can be technically and economically electrified. It is necessary for related agencies such as EAC, REF and CFR to confirm the relevance of the service area when they receive an application for license or support.

(4) Healthy management by the community

- A CEC can manage its electricity business flexibly by discussing and adjusting among the community members to adapt to the community situation, being different from REE. On the other hand, a CEC would have a risk of corruption due to insufficient control within the organization. The most difficulty for a CEC will be consensus building among the many members.
- There was a case of one REE that failed to provide continuing input of the required capital cost up to completion of its plan and disappeared from the community leaving the generation and distribution facilities on site and liabilities to its customers who had paid an initial connection fee.
- Keys to ensure healthy management with the cooperation and mutual help of the community are to ensure fairness, social equity and a transparent process of decision making as well as accountability and transparency of the accounting system.
- In order to achieve the above it is necessary to have: involvement of an external facilitator, disclosure of CEC accounting (on a notice board which may be placed at a power station or office for inspection of the accounting notebook by members), external financial auditing by EAC as regulator and CFR as loan provider, and a rule for decision making (rule of voting power) in the CEC rules.

- The electricity tariff rates cannot be decided by the CEC itself but need approval of EAC. CEC members tend to prefer lower tariff rates. Tariff rates should be based on the capital costs that include their own equity capital, interest on loans, repayment period, electricity consumption, and reserves to cope with future maintenance, replacement of equipment, and various risks that incur expenditure as well as non-paid or delayed payments of the electricity tariff.

(5) Biomass

- Land adequacy for fuel wood farming has been confirmed in the MP. Its adequacy was confirmed through the community workshops.
- Community people favour biomass power because money paid to purchase fuel wood will remain and circulate within the community. Also, most of them expect to have an additional income compared to diesel generation.
- However, their over-expectation is not correct and should be well explained. If all the members evenly share the fuel tree farming and consume 15 kWh per month per household, an additional income would be only $0.45 per household per month. However, if the fuel tree farming is undertaken by the 10% poorest households among the total members, then those farmers can have an income of $4.50 per month, with which they can manage payment of the electricity tariff. Therefore, it is important to explain these conditions to them.

5. Summary of CEC operation

(1) Feasibility of CEC

- It is impossible for a CEC to implement an electricity business without assistance in view of the need for financing, technical requirements, fairness, social equity, and sustainable management.
- If a CEC can have support in financing, technical aspects, and operation and management of the electricity business, it is considered that electrification by a CEC would be feasible.
- Eight communities out of the nine, in the workshops, preferred mini-grid implementation by CEC and not by REE.
- Reasons for the preference for the CEC option are in its cheaper tariff and an REE would incur a risk of bankruptcy. Also they expect a regional economic effect on the community through fuel tree production.

(2) Financial cooperation

- It is expected that they can bear the cost of equity capital and a monthly electricity tariff.
- On the other hand, those communities that do not have the ability to pay should not be supported because they are not mature and are not ready for electrification by mini-grid.
- For those communities that have the ability to pay, it is almost impossible to get a short-term loan (at 50% of the initial capital costs) from commercial banks even though they could get a subsidy of 25% from REF and prepare to provide the remaining 25% as their own equity capital.
- It is considered that many communities can make monthly repayment if a soft loan is provided, not as a subsidy.
- Therefore, a soft loan is essential in the financial support required for a CEC.
- Any CEC will need to take into account in its business planning, in addition to direct costs for implementation, such costs as those required for trouble resolutions, reserves for future repair work and equipment replacement, indirect costs for account auditing and other support services for the CEC. There may be an opinion that external organizations should provide support services to the CEC free of charge in view of its support for the public. However, in view of the desirability for sustainability of such supporting organizations as well as keeping an equal partnership between the CEC and the supporting organizations, the study team is of the opinion that these services should be provided on a fee basis. The CEC should pay for the services. It is recommended that such costs be covered and provided to the CEC as part of the subsidy. The subsidy will be CEC property. However, the subsidy should be deposited in an account to be supervised by an external supporting organization. Therefore, fees to DIME, repair companies, NGOs, accounting firms, and so forth will be paid from the CEC account, which is under supervision by its supporting agency, so as to prevent risks of corruption and to secure proper fund management by the CEC.

(3) Technical cooperation

The following technical cooperation is required:

- Initial planning, design, cost estimate, tariff setting

- Guidance in fuel wood farming
- Procurement, acceptance inspection of equipment, temporary storage on site
- Training in erection of distribution lines and related electrical works
- Construction training (instruction and guidance to community workers)
- Training of operators
- Training of accountants
- Training in operation and maintenance.

(4) Operational cooperation

Operational cooperation is the most important of the facilitation functions for the CEC. The cooperation items are as follows:

- Support for setting up of the CEC is required first. This is to encourage people to set up a CEC for self-help electrification.
- An external supporting organization as a third party catalyst will have roles to coordinate and facilitate to establish a fair and equitable organization. The facilitation should include, for example, determination of the service area, eligibility of CEC members, and selection of the CEC chairman, operator and accountant.
- Periodical monitoring is important, such as checking for corruption, conflict among members, and problems in cash flow, until stable and sustainable management is achieved.
- A solution function is also important as a catalyst to intervene from a fair and neutral position and judge in case of conflict and trouble.
- To check accounting.
- To check if a transparent process in decision making is ensured by participating in the annual meeting of the CEC.

6. Summary result of workshop in six pre-feasibility sites

Summary of Workshops in Six Pre-feasibility Sites

Site	Power source	Total evaluation in terms of community organization	Human resources	Ability to pay initial cost	Ability to pay monthly charge	Will for Electri-fication	Biomass planting
Srae Ta Pan	Solar BCS	PWC	P	D	PWC	PWC	-
Bu Sra	Micro hydro mini-grid	PWC	P	D	PWC	P	-
Samlout (Ou Samrel)	Hybrid mini-grid	P	P	P	P	P	P
Samlout (Mean Chey)		PWC	P	PWC	PWC	P	P
		PWC	P	PWC	PWC	P	P
Samlout (Samlout)		PWC	P	PWC	PWC	P	P
Samlout (Sung)		PWC	P	D	PWC	PWC	P
Samlout (Tasanh)		P	P	P	P	P	P
Pramaoy							
Samraong	Biomass mini-grid	PWC	P	D	PWC	PWC	P
Kampong Kor		P	P	P	P	P	P

Note: P: Possible, PWC: Possible with Conditions, D: Difficult, -: Not considered

ATTACHMENT-5 REQUIREMENTS FOR ACHIEVING SUSTAINABLE ELECTRIFICATION BY COMMUNITY ELECTRICITY CAMBODIA (CEC)

Items	Requirements	Remarks
Necessary support to set up and manage a CEC		
Financial support	■ Grant (solar BCS)	■ A 100% grant of BCS equipment may have the adverse effect of deteriorating the spirit of self-help. To avoid such risk, a leasing charge will be collected from the CEC out of the operating income of the BCS. The charge will be deposited and used for periodical inspection and monitoring by DIME and maintenance of BCS equipment by suppliers.
	■ Soft loan (some of the mini-grids)	■ Most of the households currently using battery lighting have the ability to pay in the order of $3-5 per month. However, most of them cannot afford to raise the initial capital investment in the order of $500 per household.
	■ Combination of grant and soft loans (most of the mini-grids)	■ It is also necessary to support solar BCSs and biomass gasification power that were not covered by REF as of 2005.
Supporting organization for individual projects	■ To support a CEC in its setting up and management, application for financial support, etc. ■ A CEC will contract with external supporting organizations and will use their support services on a fee basis. To facilitate such services, therefore, the costs will be included in the financial support and provided to the CEC.	■ It is essential to provide support to villagers in setting up a CEC because of the past odious history in Cambodia. ■ Support by DIME, NGOs, etc. can be expected. However, they also need funds for their supporting activities. Such expenses and fees will be added to the construction costs of electrification projects and will be provided to the CEC.
Technical and management support	■ Demand assessment, basic design, procurement, construction work, tariff setting, training for operation, periodical inspection, and replacement of equipment ■ Meter reading, tariff collection, accounting, management of reserved surplus money, account auditing, monitoring	■ It is essential to support the CEC from its setting up stage to management till one year after the commissioning, 2 years in total. ■ It is also important for DIME to support the CEC by periodical monitoring to secure sustainability of the project operation.
Public relations of support system and enlightenment for rural electrification	■ To disseminate information to all the communes in the off-grid areas about the support system ■ To enlighten the villagers about the electrification methods for communities through renewable energy ■ To enlighten users on how to use electricity such as switching off the lights before going to bed ■ To enlighten users on the safe use of electricity	■ Although these are not directly concerned with success of an individual project, they will be the key for achieving the targets for improving the level of electrification.
Requirements for success of CEC mini-grids		
Sustainable management of	■ To clearly define, in the CEC rules, the responsibility and power	■ To avoid one man control of the reserved money of the CEC by the boss.

Items	Requirements	Remarks
each CEC	of the director, responsibility of members, and the rule for decisions at the general meeting of the CEC ■ Management support by NGOs etc, for one year, who will conclude a contract with the CEC ■ Periodical monitoring by DIME (3 times in the first year, and once a year from the second year onward) ■ Each CEC will submit an annual accounts report to REF/CFR until all the loans have been repaid (certificates of cash balance and bank account should be attached).	
Demand assessment	■ A standard demand is 100 W per household. ■ A simple hearing survey on the desired use of electricity would often result in a demand several times the above standard level. It is important to examine the demand level upon evaluation of the application for support.	■ An overestimate of demand will result in oversizing of generating equipment and shortfall in operating income, which would lead to a risk of bankruptcy of the CEC. ■ On the contrary, an underestimate of demand will cause a shortage in the generating capacity and frequent black outs.
Securing access to electricity	■ To provide villagers with equal opportunity for membership of a CEC (a minimum of 50% service ratio in the service area is a condition for CEC support) ■ To encourage the CEC to accept equity in kind as labour force since the initial connection fee of about $50 or initial equity is a barrier for the poor households to join the CEC ■ To install a BCS powered by the mini-grid.	■ Explanation at community meetings, and recruitment of members of the CEC ■ Monthly tariff will be about $0.50 if use is limited to one energy saving light and, therefore, such poor households will no have problem in ability to pay a monthly tariff. ■ The BCS will spread the electrification effect to the entire community and the power supply to the BCS during the daytime will lower the unit generation costs of the CEC.
Raising equity	■ An initial equity of $50-100 per household should be deposited through saving activities for about one year. This deposit will be the condition for support by CFR.	■ Those communities that cannot raise the initial equity are judged as not yet mature for electrification and, therefore, will be excluded from the candidates for support. ■ Such villages should continue the present battery lighting until getting mature enough to provide their own equity.
Tariff collection	■ To stop power supply to those households not paying or with a delay in monthly payment ■ Crosscheck among the metered consumption, amount billed, and money collected.	
Management of reserved money	■ To open a bank account under the name of the CEC ■ To deposit the money collected immediately after collection, and not to keep cash in the hands of the accountant	

Items	Requirements	Remarks
	■ To use the deposits in the bank account as a source of micro-crediting for improvement measures for household income (however, such withdrawals and use of the reserved money should need concurrence of CFR in order to avoid defaults in repayment of such credits due to an unplanned crediting scheme) ■ Internal auditing of accounts and a report to the general meeting of the CEC ■ Account auditing by external support agency such as DIME.	
Evaluation by REF/CFR of the suitability of applications for projects	■ Assessment of organization	■ Examination if there is a supporting agency like an NGO for each individual project ■ Experience and suitability of the director, operator, and accountant of the CEC ■ Rules of the CEC
	■ Technical evaluation	■ Appropriateness of demand assessment, service area, installed capacity of power generation, and fuel supply plan
	■ Environmental evaluation ■ Financial evaluation	■ Location within the environmental protection areas, plan of micro-hydro to discharge the minimum flow during the dry season, method of final treatment of wastewater of biomass gasifier ■ Confirmation of arranging plan of own equity ■ Tariff level, repayment schedule of loans ■ Plan of management of the reserved money (bank account, account reporting, and account auditing)
Appraisal by EAC and issue of REE license	■ Evaluation of conformity to technical standards of generation and distribution facilities ■ Assessment of tariff system and level	■ EAC will evaluate after completion of the mini-grid. ■ If the tariff level is sufficient to recover the capital costs including repayment of loan
Requirements for success of solar BCS		
Sustainable management of BCS	■ To clearly define the responsibility of the director, members, and BCS operator of the CEC ■ Periodical monitoring and management advice by DIME (3 times in the first year, and once a year from the second year onward) ■ To inform suppliers in cases of equipment trouble ■ DIME to report to CFR on account auditing and remit the lease charge of the BCS	■ Daily works are only by the BCS operator ■ DIME provides supporting services on a fee basis. Out of the operating income of the BCS, the CEC will pay a leasing charge to REF via DIME after deducting and paying the fee to DIME. ■ Repair charges by suppliers will be paid out of the lease charge remitted to and deposited at CFR.

Items	Requirements	Remarks
	■ To define the responsibility in the rules of the CEC when the BCS equipment is damaged or stolen	
Access to BCS	■ When a village consists of multiple sub-groups, a small sized BCS may be installed for each group. ■ It is a condition for support that more than 20% of the households plan to use the BCS.	■ Any delivery system for batteries is left to the market mechanism.
BCS facilities	■ To utilize school buildings, pagodas, or space under houses as shelter for BCSs, in order to save initial costs ■ Battery charging operations may be undertaken by villages on a voluntary basis.	
Ability to buy battery	■ Micro-crediting services may be provided to those who cannot afford to buy batteries. Such credit can be sourced from the operating surplus of a BCS after deducting necessary expenses from the battery charging fees.	■ Small 6V batteries used for torch light will also be charged at BCSs. Such small batteries are a means for livelihood and can be positioned as a step towards the introduction of battery home lighting.
Ability to pay charging tariff	■ If ability to pay is not sufficient, priority should be given to support for a livelihood improvement program rather than electrification.	■ Such people cannot be BCS users for the time being.
Financial support	■ BCS installation with a grant is required.	■ A BCS, if installed with soft loans, will need a high charging tariff compared to a private diesel BCS and will not be used.

ATTACHMENT-6 INSTITUTIONAL STRENGTHENING OF MINISTRY OF INDUSTRY, MINES AND ENERGY (MIME)

Institutional strengthening consists of (1) securing staff, (2) developing staff, capacity building and (3) securing the funds for the activities. The study team proposes plans for institutional strengthening of the rural electrification sector and the energy department of MIME and its provincial office (DIME: Department of Industry, Mines and Energy) as follows.

(1) Securing DIME staff

In promoting the electrification of the off-grid areas, the role of DIME to be fulfilled is large, especially in the enlightenment of CEC groups and the monitoring of projects. However, the numbers of DIME staff engaged in the rural electrification sector is limited. Following the policy of the decentralization of power enacted in 2005, the organization of DIME is under review.

We propose at least 1 staff member working full time for the rural electrification to be dispatched to the DIME to include a lot of off-grid villages.

(2) Institutional strengthening

It is required that the capacity for planning and implementation of the policy and investment plan of MIME/DIME should be improved. Capacity building and instruction is required for the following items.

- Preparation of implementation rules and regulations for the promotion of rural electrification (division of roles for related organizations, how to prepare funding, permission matters)
- Preparation and supervision of detailed rules for implementation support by CEC/REE
- The evaluation of requests for proposals (RFPs), recruiting RPCs (REE covering the wide area) and REE in the specific communities, the selection of RPC/REE and the supervision of the achievements of the enterprises
- Identification of the risk to be born by the Government and the enterprises and the study of the plan for risk decrease (favourable and incentive treatment, such as reduction and exemption of tax, compensation of income)

(3) Capacity building of staff

MIME and the organizations for assisting the rural electrification such as REF and EdC will educate and train the DIME, NGOs and the consultants who assist and instruct CEC/REE regarding the items listed below, utilizing the EdC training center in Phnom Penh.

- Institutions for rural electrification
- Advertisements and enlightenment, establishment of CECs, instruction for operation
- Preparation of electrification plan and application for assistance
- Design and procurement
- Construction
- Operation and maintenance
- Operation of electricity businesses (inspection of electricity meters, invoicing, collecting charges, accounting, fund management, auditing).

They will develop renewable energy engineers through the construction and operation of the pilot project (technical assistance will be required in the stages of design, procurement, construction and operation).

(4) Plans for fund procurement

It is essential to secure funding for activities in order to strengthen the organization and give full play to their ability.

1) Funds for electrification sector

- Imposition charge on grid users (inner assistance) and distribution to rural electrification

- Exemption[1] of customs and VAT for equipment for renewable energy
- Installation of financial funds (soft loans, cooperation with MEF)[2]
- Securing of funds from donors (especially soft loans)

2) Funds for activities of MIME

- Ordinary budget from MEF
- Construction fund for a pilot project and technical assistance (from MEF and donors)
- General campaign for enlightenment (MEF budget in the meantime, profit from the operation of the pilot project, implemented with government funding, after a few years)
- Fact finding surveys for rural electrification and monitoring of the progress of electrification (request to SEILA).

3) Capital for the payment for technical and administration service by DIME staff

The country of Cambodia is large compared with the population. The road and communication situation in the rural area is poor. Utilizing the DIME staff who stay in each provincial capital leads to the effective use of time, funds and manpower in order to manage the rural electrification project all over the country under such circumstances. Dispatching NGOs, consultants or suppliers from capital based on the contract takes time and involves moving costs. This makes prompt and effective service difficult. Accordingly DIME should take charge of general administrative tasks such as enlightenment, inspection, accounting audit and monitoring. The specialty organizations such as NGOs, EdC and suppliers should be appointed to tasks such as assistance with the establishment of CECs, instruction on operation and maintenance service for equipment.

The part of the subsidy granted to CEC/REE should have its purpose limited to the technical assistance and administrative costs such as monitoring. It should be managed in the bank account of the CEC. The CEC/REE, by submitting the necessary documents in conjunction with the progress of the project, should pay compensation, such as a daily allowance to the public officers, NGOs and so on engaged in the promotion of renewable energy, from the bank account. This system should be incorporated in the institution for assistance. DIME will take charge of the following fare-paying services.

- A price should be paid for the services of patrol inspection, maintenance, instruction and accounting audit for the solar BCSs by the DIME staff (approximately $67 per service on average). The supplier should be paid by using the deposit of the lease fee ($200 per location per year) managed by the assistance organization in case repair work beyond the capacity of DIME staff is required.
- The appropriate price should be paid by DIME staff from the profit of the electricity charges, for the services of patrol inspection, instruction about the CEC mini-grid, and accounting audit.

[1] For this, incentive measures are desirable for licensed production of renewable energy equipment such as biomass gasifiers. Of gasifier costs, the development cost is larger than the manufacturing cost. Although it depends on negotioation, a large “payment up front” will be expected.

[2] Establishment of environment tax (ecotax) and distribution to renewable energy projects can be considered as an idea. However, such an idea may affect not only electrification projects but also all economic activities through fuel costs for cars and motor bikes, and electricity tariffs. Further, distribution is not only necessary for the rural electrification sector, but also for other envirionment related projects. Therefore, such an ecotax should be examined as an integrated policy of government. In this MP, it is just listed as one of the future issues to be examined.

ATTACHMENT-7 ACTION PLAN FOR PROMOTION OF RURAL ELECTRIFICATION

The Study Team proposes that MIME should prepare and execute the following concrete action plan in seven categories to implement the recommended plans in this master plan.

No.	Classification	Action plan for the 1st period	Action plan after the 2nd period
1.	Policy level	1) Review, approval and announcement of draft plan for grid extension that the Study Team prepared, as well as monitoring and renewal 2) Preparation for establishment of institutional infrastructure for ancillary charges 3) Establishment of the institutional infrastructure for progress monitoring of the MP	1) Commencement of the effect of institution for ancillary charges 2) Monitoring of the progress of the MP 3) Renewal of the MP every 4 years 4) Study of renewable energy promotion law (including environment tax)
2.	Organization	4) Preparation for the establishment of a supplemental fund for REF which aims to provide fund assistance such as soft loans and technical assistance for solar BCSs and biomass power	5) Establishment and commencement of operation of supplemental fund for REF 6) Establishment of a counselling room for renewable energy in the MIME energy technical department 7) Dispatch of a duty officer for enlightenment and diffusion of Renewable Energy Technology (RET) to each DIME
3.	Funds	5) Promotion and realization of the distribution of financial funding and exemption of tax to MEF	8) Assistance to the inspection capacity building of the intermediate bank
4.	Engineering, Training	6) Capacity building of MIME/DIME staff through the implementation of a pilot project 7) Preparation of a technical standard, such as an emission standard for biomass power, through the implementation of the pilot project	9) Implementation of development assistance with applied technology (MIME) and promotion activities (DIME) for renewable energy
5.	Fund procurement	8) Promotion of licence production for the gasifier in the pilot project	10) Standardization of the specification and use of electricity meters (in association with EAC and EdC) 11) Plan for promotion of concrete electricity poles
6.	Advertisement, Education	9) Implementation and operation of the pilot project applying new technology and a business model that are possible for development all over the country 10) Distribution of a Visual Guide that the Study Team is preparing for DIME and communes	12) Introduction of renewable energy by newspaper, TV and so on, and publication of a periodic journal (ex. RET News) 13) Establishment of a website introducing the latest information about renewable energy 14) Holding of a seminar / workshop for the community and REE The result should be shown on the website.
7.	Assistance for organization (CEC)	11) DIME should take charge of the initial enlightenment activity for the community.	15) NGOs should take charge of the assistance with CEC establishment and operation instruction for one year after the commencement of operation.

No.	Classification	Action plan for the 1st period	Action plan after the 2nd period
			16) Periodic monitoring after the commencement of operation should be conducted by DIME.

ATTACHMENT-8 SUPPORTING SYSTEM FOR PROMOTION OF RURAL ELECTRIFICATION

In order to further promote rural electrification in Cambodia, a fund (referred to as CFR (Complementary Functions to REF) in this MP) will be established to complement the functions of the existing REF by the year 2009. The JICA study team recommend that under the harmonious operation with REF, CFR will support the electrification in the off-grid areas in particular in accordance with the principles described below:

(1) Eligible Organizations to Support

CFR will support those CEC/REEs who wish to implement electrification of their community in accordance with the supporting system that MIME introduces and provides information for.

1) REE

When REE undertakes a rural electrification project, the responsibility of the electricity business and risk taker are clear. However, there was an example of an REE where the REE became bankrupt and escaped responsibility, and those people who just paid the initial connection fee could not receive electricity, except for only one month, and could not get compensation. At the village workshops held in December 2005, 9 communes out of the 10 expressed their desire to choose a CEC rather than REE. Of the 9, the participants at 6 communes chose CEC although they could not manage to raise the initial equity, saying that an REE can hardly be credible[3].

2) CEC

A CEC (Community Electricity Cambodia) body is a cooperative to be registered with the Ministry of Cambodia. However, its nature is different from ordinary cooperatives in such aspects that the members are managers of the electricity business on one hand and are beneficiaries of such business on the other hand. As managers they have to balance the operating income from the electricity tariff with expenditure for operation and maintenance of the power station as well as loan repayment. Since the term “cooperatives” is associated with odious forced labor in their past history, a special naming of Community Electricity Cambodia has been devised in the English report. However, its real organization is as a self-motivated cooperative organized without external pressure and compulsion.

Cooperative members will not take risks beyond their equity. There is a concern that such an organization will become irresponsible. It is an issue to clearly define the responsibility in order to facilitate decision making by the leader in accordance with the situations a CEC may face.

Since the rural communities in Cambodia lack experience of collaboration among the community members, external support/facilitation in 1) finance, 2) technology, and 3) CEC management is essential. It will be necessary for the external facilitators to provide sufficient support for each CEC, such as setting up the CEC, training of O&M and management staff, training of initial management for one year after commissioning, periodical inspection and instruction on maintenance work for 5 years after the commissioning, account auditing once every year, technical support upon replacement of power generating equipment 10 years after the commissioning, and so forth.

3) Regional Power Company（RPC）

Within the assumed off-grid areas in the year 2020, 4 regional mini-grid schemes have been identified that cover the whole area of one or two districts. All of these areas are located in remote areas or are situated on the opposite side of the Mekong River or Tonle Sap River from the provincial capital and 22 kV distribution lines will hardly cross these rivers by the year 2020. Accordingly, the possibility of grid extension to these areas by the year 2020 is very low. On the other hand, these areas cover from 6,000 to over

[3] The opinion seems to have been influenced by the past odious history.

10,000 households and the ability to pay of the people there is relatively high. Electrification projects for these large areas are difficult for an ordinary REE/CEC because of the required scale of initial investment. In these areas, a joint implementation by RPC and REE/CEC will have various merits[4]. The RPC will invest in and manage the power station and 22 kV distribution lines while the REE/CEC will buy electricity from the RPC and construct and manage low voltage distribution lines to retail electricity to consumers in the respective service areas.

RPC is a kind of private REE. It is possible for a government agency such as DIMR or provincial government to have a partial share in such an RPC. However, the Electricity Law prohibits the government agency from controlling and managing the RPC by having a majority shareholding.

A regional mini-grid, if constructed, will have such effects as efficient electrification of the whole region, reducing burdens on the CEC, and promotion of electrification. In those areas where many mini-grids of either REE or CEC will be required adjacent to each other, a regional mini-grid should be planned with government initiative and should publicly invite private investors for implementation. DIME will select an RPC through tendering and an REE or CEC will undertake low voltage distribution for retail.

(2) Electrification Types to Support[5]

- Mini-grids[6]
- BCS (*Social Electrification*)[7]

The following three implementation methods of rural electrification will be adopted as combinations of items (1) and (2) above.

- To achieve efficient electrification with limited financial support to the REE,
- To achieve electrification of rural communities by supporting a CEC where a profitable electricity business cannot be expected, and
- To achieve the village electrification level of 100% under a *Social Electrification Policy* by providing BCSs as a grant scheme.

(3) Criteria for Selecting Communities to Support

Selection Priority

In view of the electrification policy for the off-grid areas with community initiative, it is the governing principle to take up and support electrification projects in the order of receiving applications that satisfy the supporting criteria. When there are too many applications to support with the available financing resources (subsidies and soft loans), these applications will be prioritized with the following criteria:

- Such large schemes that require financial support exceeding the remaining budget should be referred to the CECs to phase them down to smaller sub-schemes. A scheme that is difficult to phase down or that exceeds the budget even after phasing down will be registered in a waiting list to wait for a budget arrangement.
- Some applications will be screened out by the planning maturity (service area within the

[4] In addition to the merit of scale, the regional mini-grids will have such merits as to release the CEC from the most troublesome power generation work, to save the construction costs of reserved generation capacity by sharing such capacity among the wider region, to facilitate gradual extension of the supply areas, and to facilitate the addition of generating units in accordance with supply requests from latecomers and increase in the demand.

[5] The existing REF will support SHS, mini-grids by micro-hydro or diesel power, and grid extension. Biomass mini-grids and solar BCSs will not be supported at present. Since an REF is designed to have a grant function at 25% of capital costs, it has become the most important issue to create a loan function that complements the REF.

[6] With mini-grids it is possible to supply power for such economic activities during daytime as BCSs, water supply pumps, rice milling machines, irrigation pumps, handicraft industry, and so forth. Mini-grids should be planned not only for achieving electrification for lighting purposes but also to supply economic activities during the daytime as part of village development projects to improve household income.

[7] A total of 1,720 villages have been identified by a GIS study as candidates for a BCS. However, there is a possibility that this number of BCS candidates would sharply decrease when the latest diffusion level of battery lighting and the number of existing BCSs in each village are known countrywide through the Seila village survey.

community, level of electricity demand, level of required tariff, etc.) and the maturity of the CEC (whether the CEC has been established, whether equity has been raised, etc.).

- The applications that have passed the screening above will be prioritized based on the ratio of beneficiaries within that community (to be higher than 50% in the mini-grids and higher than 20% for a BCS). (This criterion will in general favor CEC schemes rather than REE schemes that give top priority to investment efficiency rather than service coverage.)
- The applications above will further be prioritized, if necessary, by the number of beneficiaries. (This criterion will favor financing efficiency with limited sources for support. It will favor REE schemes that electrify more households than REE schemes with the same amount of supporting money.)
- Mini-grids or BCSs, whichever is the lower in achievement of annual electrification targets, will be given priority.

Eligibility for Support

Upon receipt by REF/CFR of applications from a CEC/REE, suitability of the electrification plan, assumed tariff level to recover capital investments, and capacity of the implementing body (CEC/REE) will be evaluated. At the evaluation, eligibility and priority in support will be judged based on the following:

- A mini-grid scheme will be eligible only when it will service a minimum of 50% (target is 80%) of the total households in the community[8]. When the supporting budget is short, the applications will be prioritized by the service ratio (from the highest ratio of household coverage).
- It is recommended that a mini-grid with biomass gasification power has a number of beneficiaries greater than 200 households. However, if it is judged possible to manage a smaller scheme based on the plan and tariff level, then a smaller scheme of about 100 households will also be eligible[9].
- A BCS scheme[10] will be eligible only when more than 20% (target is 25%) of the village or sub-village wish to introduce battery lighting[11]. When the support budget is short, the applications will be prioritized by the ratio of such households planning battery lighting.

(4) Eligible Facilities and Services to Support

- Eligible costs are construction costs for electrification facilities for lighting at night times including costs to buy equipment and materials and to install these or erect facilities (generating equipment and facilities, 22 kV and 400 V distribution facilities), as well as costs for individual meters and service lines including in-house wiring, fees for technical and management support services by NGOs etc. for the CEC (for design, procurement, guidance of construction works, O&M, etc.).

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8 The minimum unit of supply area (a denominator to estimate household electrification level) is village, followed by commune, and district. The geographic distribution of households within the supply area varies much from village to village or from commune to commune. If an application with a household service ratio at lower than 50% is evaluated by the REF/CFR and it is found there is a reasonable background to the low level, such an application will also be taken up as an eligible application for support. It is considered to be a rare case that the criterion of household service ratio at greater than 50% will hamper electrification of such communes where an REE would have an interest to participate. An example is in the case of Kampong Kor where all the households are gathered along both sides of the main road. Accordingly, the service ratio there will not be affected by the investment efficiency (that is, a check by service ratio is not required in judging the eligibility of such a village), but it will be controlled by the tariff rate and ability to pay of the people.

9 It is not necessary to set an advised scale for a mini-grid with micro-hydro.

10 In the Master Plan, criteria for BCS installation are established as those villages 1) that have no BCS within the village, 2) people have difficulty in battery charging, including having a BCS in another village nearby, 3) the actual diffusion level of battery lighting is lower than 20%, and 4) more than 20% of the villagers (including existing users) plan to introduce battery lighting.

11 In the the case of a BCS for Srae Ta Pan village, the village is geographically divided into two sub-groups. It may be necessary to consider either introduction of battery collection-charging-delivery services or installation of smaller BCSs, one to each sub-group. If two small BCSs are installed, fencing works around panels, BCS shelters and operator salaries, if paid, will increase compared to one larger BCS. Also, in this village most of the people own a 6V small battery as a torch light source but they cannot afford to buy a 12 V battery for home lighting. Accordingly, as the first step, charging services can be provided for these 6V batteries at a rate slightly lower than market prices (for example, equivalent to Riel 1,500 for a battery of 12V-50Ah). In this case, there will be a certain operating surplus after deducting the necessary expense for BCS operation. The BCS leasing fee will be paid out of the surplus.

- Costs of BCS equipment (including design and installation costs, initial training, and monitoring during the defect liability period for one year after commissioning) are also eligible.

(5) Level of Financial Support

Mini-grids

- Mini-grids will be supported by adopting a certain level of financial support[12] like an REF, in order to achieve efficient improvement of the level of electrification[13]. However, it is desirable, from the viewpoint of encouraging self-help development, to gradually reduce the level of support during the Master Plan period up to 2020. Accordingly, the proposed level of financial support should be reviewed and revised periodically adapting to the latest financing capacity of rural communities in Cambodia.
- Beyond 2020: It can be expected that the household income would be improved in those villages where BCSs are installed under *Social Electrification*. Again, the level of financial support should be reviewed and revised to adapt to the actual situation of Cambodia in order to achieve the target level of 70% of the household electrification by year 2030.

BCS

- BCSs will be subsidized at 100% of the equipment costs as *Social Electrification* except for land, fencing for solar panels, shelter for the BCSs, and operation and maintenance. A minimum leasing charge in the order of $200 per BCS (1.14 kWp) on average will be imposed to generate cash required for periodical inspection, monitoring, account auditing and repair.

(6) Sources of Finance

- Government revenue (administrative costs of REF and DIME)
- Grant of REF (WB, GEF)
- Exemption from import customs on the renewable energy equipment (mostly 15% of CIF of solar equipment, micro-hydro equipment, biomass gasification power equipment, etc.) and VAT (10%) from the viewpoint to promote rural electrification and utilization of clean energy as well[14]
- Cross subsidy (tariff surcharge) from the grid users countrywide
- It is desirable to exempt CECs from enterprize tax
- Grants, soft loans, and technical assistance from donor agencies.

(7) Financial Supporting System

- The REE mini-grids will be supported on the basis of subsidy level of REF (25% grant). REF expects that the rest 75% be financed as equity 25% and 50% by bank loans. In the

[12] The level of financial support will not be adjusted by the ability to pay. Support to such projects will be given priority as can be implemented with a fixed level of financial support. This is to maximize the improvement of electrification level by efficient use of the limited support fund. However, the fixed level of financial support will be set up for each type of power source (micro hydro, biomass, diesel, solar BCS, etc.) and implementing body (CEC or REE or RPC).

[13] Those poor households living inside the planned supply area of mini-grids can enjoy electricity at a expense of $0.50 per month much lower than for the battery lighting if they limit the electricity use to one 7 W energy saving light for 4 hours a day (0.84 kWh per month). One household will be required to raise an initial equity of about $100. It is encouraged for CEC to have discussion at a CEC meeting to accept labour force as equity in kind from such poor households.

[14] The revenue by import customs and VAT will increase along with the progress of electrification. As a result of the proposed tax exemption, the tax revenue will not increase on short-term but will increase on medium to long-term. (1) The tax exemption (= financial burden) has the significance for the government as 1) use of renewable energy that has less environmental load, 2) rural electrification, rural development, and mitigation of urban-rural divide. That is, the exemption will have a controlling effect to future financial expenses of the government for environmental remediation measures and rural development by promoting rural electrification through renewable energy. (2) From the viewpoint of import customs, 1) the exemption will not decrease the customs revenue since there will be no import of renewable energy equipment and no customs on such equipment unless the rural electrification through renewable energy is implemented as a government policy. 2) An increase in the import customs will be expected by the increase in the import of electric appliances along with the progress of rural electrification. (3) From the viewpoint to maintain the necessary tax revenue, future increase in the income tax and corporate tax will be expected as a result of the improvement of the income level and promotion of industry to be achieved through the rural development.

case of renewable energy that is capital-intensive in its nature, the basic level of financial support is set at equity 25% and loan 60%.

- In the case of mini-grids with micro-hydro, the ability to pay of the people is relatively low for its characteristics of its potential areas in a remote mountainous region. In addition, its average cost is as high as $1,229 per household on average. Accordingly, it is difficult to promote the mini-grids with micro-hydro at the same supporting level with REF. A level of financial support by exemption of import customs on equipment, subsidy at 50%, and a loan of about 40% of the capital costs would be required. In such a high subsidy scheme, an implementation by REE is not appropriate and it should be implemented by CEC as a principle. It is essential for external facilitators to support setting up and management of a CEC and to provide technical support by external experts.
- A mini-grid of a CEC with biomass gasification power would cost some $592 per household on average (for a scale of 200-1,000 households including costs for CEC support). This initial investment cost may be arranged, for example, in the order of $80 as CEC's own equity of (including labour force as equity in kind) tax exemption at $47, subsidy at $135, and soft loan at $330.
- 1) The lifetime of small scale gasifiers available in the world market on a commercial basis is reportedly of the order of 10 years. 2) With the longer repayment period, monthly repayment of soft loans by the CEC will become smaller. However, a repayment period of 20 or 30 years is too long for small scale electrification projects. 3) If a long-term loan for 30 to 40 years is available, a two-step loan may be provided for a repayment period of 10 to 15 years. In that case, the two-step loan may be repeated two or three times during the repayment period of the original external loan. Therefore, a repayment period of 10 to 15 years is desirable for a loan to a CEC. As for an interest rate to a CEC, a low rate of about 3% is desirable. However, it would remain at around 7% even if a foreign loan of very low interest rate is provided. In such a case, it will be necessary to lower the net interest rate by mixing it with subsidy, for promotion of the electrification by the CEC/REE.
- BCS equipment will be installed with 100% subsidy. The charging tariff will be set within the prevailing market price (Riel 1,500 on average in 2004/05) in the off-grid areas. If it is installed with a loan, the required tariff will be too expensive for beneficiaries to use the BCS and pay for charging. In view of the objective of *Social Electrification* and installation with 100% grant, such a BCS will be managed by a CEC as a principle. Support by an external facilitator will be required in setting up and management of the CEC. According to a trial calculation by the study team, the level of leasing fee of the BCS equipment will be limited to such amount that would recover costs required for periodical inspection and maintenance services (about $200 per BCS per year) even if the charging operation is undertaken by a villager on a voluntary basis. However, minimum surplus money would remain with the CEC. Such surplus may be used as a source of micro-credit for promoting battery purchase and measures for livelihood improvement.

(8) Tariff System

- The tariff level should be established based on the power source and scale of mini-grids and the level of financial support.
- As a principle, a tariff system of diminishing rate is adopted, that is, the more consumption the lower the rate. A lifeline tariff rate for the first block of consumption up to 1 kWh per month may be introduced, for example, one half of the second block over 1 kWh. However, it would make tariff calculation complex. In the MP, the access to electricity of the poor households will be secured by encouraging a CEC to accept such poor households in order to raise its equity in kind by using the labour force.
- The diminishing rate is, for example, to set a rate at Riel 1,500 for the first block of 0-10 kWh and Riel 1,350 for the second block of over 10 kWh (one who consumes 15 kWh will pay for the first 10 kWh also at a rate of Riel 1,500). It is recommended that a further low rate, of around Riel 1,000 for example, be introduced and applied to daytime demand[15].

[15] In the existing scheme of Anlong Ta Mey village, the CEC sells electricity to a BCS operator at Riel 1,100 per kWh.

ATTACHMENT-9 SUPPORT ACTIVITIES FOR COMMUNITY ELECTRICITY CAMBODIA (CEC) FOR SETTING UP AND MANAGEMENT

Having feedback from the villagers workshops held at 10 communes in December 2005, support activities required by the CEC for setting up and management are described below:

1. Support Depending on Community Maturity for Electrification

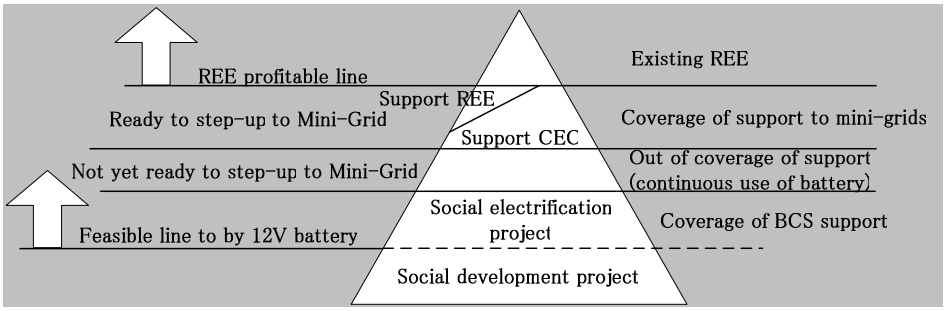
Staged support will be implemented in response to the maturity for electrification of the target area.

- **Maturity for Electrification:**

  The maturity for electrification of a community will be classified based on the economic activities, ability to pay for electricity and electricity literacy (knowledge and understanding of electricity, experience of using electric appliances, ownership level of battery lighting and TV).

Maturity Levels for Electrification

Maturity for Electrification		Policy Measures
3	Users of the national grid	These users will lead the proposed cross subsidies.
2	Users of REE mini-grids	Connect to the grid in the future.
1+	Users of battery lighting and having ability to pay for the initial equity	To be electrified by REE with financial support
		To be electrified by CEC with full support
1-	Users of battery lighting but having no ability to pay for the initial equity	Out of the scope of support targets at present To continue battery lighting until achieving ability to pay for the initial equity
0+	Having no battery but having ability to buy a battery if micro-crediting is provided	To be supported with a BCS (*Social Electrification*)
0-	Having no battery and no ability to buy a battery even if micro-crediting is provided	Out of scope of BCS program Priority is to be given for social development activities



Electrification Support Concept in Off-grid Areas

- **Villages to Support**

  The maturity levels 0+ and 1+ for electrification will be supported. The level 0+ is positioned as *Social Electrification*. The operating surplus from BCSs will be used as a fund for micro-crediting for those villages who wish to buy 12V batteries. Thus the target level of 25% of village electrification will be pursued.

■ **Villages not Supported for Electrification**

The maturity levels 1- for electrification will not be supported. This class of village should continue the use of battery lighting to improve electrical literacy until gaining the ability to pay for the initial equity to upgrade. However, those villages where more than 50% of the households are at Level 1+ will be planned for electrification by mini-grid, and will be supported. In such villages, households belonging to class level 1- should be encouraged to join the CEC by accepting their equity raising in kind as labor force and or, in the case of biomass mini-grids, by giving them priority in contracting fuel tree farming.

2. Outlines of CEC Support Activities

(1) Basic Vision of CEC Support

- A CEC will be supported until it achieves independent and sustainable management. The support by NGOs etc. will be provided for 2 years from its setting up. Thereafter, DIME will provide services for periodical inspection and monitoring.
- The support will be initiated before the CEC exists. Accordingly, the support will be provided in the following three stages (refer to Figure 13 of the main text):
  1) Enlightening Stage: Dissemination and enlightenment from the support system to stimulate motivation for self-help electrification (cf announcement for boarding)
  2) Preparation Stage: Preparation towards setting up a CEC (cf application for boarding and ticketing)
  3) Setting up and Management Stage: Support until independent management is achieved (cf auxiliary power for take off)
- At the initial stage, a wide range of support will be required. Along with improvement of the management capacity of the CEC, the range of support will be narrowed down. Ultimately the CEC will manage independently (cf stable horizontal flight).

(2) 3 Elements of CEC Support (refer to Figure 11 of main text)

- The CEC support has the following 3 basic elements:
  1) Financial support
  2) Technical support
  3) Management support/facilitation
- Financial support:
  1) Long-term loans with a low interest rate
  2) Subsidy (grant)
- Technical support:
  1) Technical support in design, cost estimating, procurement, construction
  2) Training for operation and maintenance
- Management support/facilitation:
  1) Enlightenment for stimulating motivation for self-help electrification
  2) Support for organizing a CEC (role to foster)
  3) Monitoring (role of looking after)
  4) Mediation, disputes, and technical judgment (role of solution)
  5) Confirmation of accountability of accounting (role of account auditing by DIME, etc.)
  6) Confirmation of decision making process to secure accountability (role of external monitoring).

(3) Support Mechanism (refer to Figure 12 of main text)

(4) Support Steps, Responsibilities and Roles

	Steps	In-charge	Supporting Activities
Enlightenment for CEC Setting up	Dissemination and enlightenment of the support system	MIME/DIME REF/CFR	・ Enlightenment using Visual Guide for electrification and setting up CECs under the support system ・ Commune is treated as a window of opportunity for such activities.
Preparation 1 for CEC Setting up	Preparatory meeting with Commune representatives	・ Commune Chief as representative ・ Members of Commune Council ・ Members of Commune Board ・ Village Chief	・ The members listed on the left will study the concept of electrification (supply area, etc.) as the representatives of the commune residents. ・ DIME may participate upon request from the Commune. ・ District and Province officials may also participate upon request from the Commune.
	General meeting for explanation	- ditto -	・ As a result of the preparatory meeting, the concept of electrification and the support system will be explained to the commune people. ・ It aims at confirming the will to join a CEC and achieving consensus among the community.
	Village survey	- ditto -	・ In accordance with the Visual Guide, necessary village surveys will be carried out. ・ The household survey includes number of total households, number of households who wish to join CEC, number of households who are using battery lighting, monthly expense for lighting including purchase and charging costs of battery, monthly household expenditure, etc.
	Pre-consultation to DIME	- ditto -	・ Consultation if the project deserves full scale study. ・ When there is a possibility of joint implementation of the electrification with neighbouring communes in view of the village distribution around the proposed supply area, DIME may advise the applicant to sound out the will of adjacent communes and arrangenecessary coordination. ・ DIME may directly support the applicant in preparing the application form or may introduce an appropriate NGO etc.

	Steps	In-charge	Supporting Activities
Preparation 2 for CEC Setting up Application	Preparation of a business plan	- ditto -	・ Confirmation of the number of households who wish to join the CEC; ・ Hearing survey on the type and consumption (Watt) of electrical appliances that each household plans to use; ・ Demand assessment; ・ Defining the supply area; ・ Determining the installed capacity of power generating equipment; ・ Estimate of the length of distribution lines; ・ Preliminary estimate of project costs ・ Preparation of draft arrangement plan of initial capital costs in accordance with the support system; ・ Preparation of draft tariff rates in accordance with the support system; ・ Preparation of a business plan; ・ Confirmation of members of preparatory committee for setting up a CEC, and obtaining signatures from the households who will join the CEC; ・ Preliminary election of CEC officers (Director, operator, accountant); ・ Preparation of the rules of the CEC.
	Preparation and submission of application documents (application)	・Preparatory committee for setting up CEC	・ Submit the business plan above to the CFR.
	Evaluation	・ REF/CFR	・ Evaluation ・ CFR may make a field inspection and ask the CEC for adjustment of the application documents.
Preparation for Management and Construction	Setting up CEC	・ CEC	・ A general meeting will be held to set up the CEC, confirm CEC members, elect the officers, and approve the rules of the CEC. ・ NGO etc. will support the meeting as an external monitor.
	Pay in the initial equity	・ CEC	・ The initial equity of the CEC to be raised by the members will be deposited in a bank account to be opened under the name of the CEC.
	Remit subsidy and loan	・ CFR	・ After confirmation of the deposit from the bank, CFR will remit the subsidy and loan to the CEC account.
	Procurement and construction works	・ CEC	・ CEC will implement procurement and construction works under the technical guidance of NGO, etc.
	Training	・ NGO, etc.	・ NGO etc. will provide technical and management training services to the CEC in fuel tree farming, procurement, on-site inspection and temporary storage of equipment and materials, electrical works, construction works, operation, accounting, O&M.
Management	Commencement of operation		

	Steps	In-charge	Supporting Activities
	O&M	・ CEC	・ The CEC is the manager of the commune electricity business and will undertake operation and maintenance with full responsibility with the support of NGO, etc.
	Periodical inspection, monitoring, external account auditing	・ DIME ・ REF/CFR	・ DIME will provide these services to the CEC once a year on a fee basis. The CEC's responsibility to pay such external support services will be included in the conditions for financial support by CFR. ・ CFR may inspect and audit the accounting of the CEC by itself. However, in principle CFR will sublet these services to EdC, NGO, private consultant, etc.
	Maintenance	・ EdC, suppliers	・ DIME or CFR will introduce EdC, NGOs, private consultants, contractors, or suppliers upon request from the CEC for maintenance services. ・ The costs therefore will be paid out of the money to be reserved for future replacement of equipment and repair. ・ In the case of a solar BCS, such costs will be paid out of the reserved money that REF reserves from the lease charge.
	BCS leasing charge	・ DIME	・ Upon periodical inspection by DIME (once a year), the CEC will send the annual lease charge to CFR through DIME out of the money to be reserved from the monthly operating income with top priority.
	Account reporting	・ CEC	・ The CEC will undertake accounting with full responsibility and will report to CFR once every year.
	Loan repayment	・ CEC	・ The CEC will remit the monthly repayment of the loan out of the operating income with top priority.

ATTACHMENT-10 COMPLEMENTARY FUNCTIONS TO REF (CFR) FOR PROMOTING RURAL ELECTRIFICATION BY BIOMASS AND OTHER RENEWAL ENERGY

1. Function
   1) CFR will extend financial assistance and technical assistance.
   2) Financial assistance is basically for the capital cost needed for construction of the project. Operational cost is expected to be covered by its own revenue.
   3) Conditions of financial assistance given to projects will be fixed and not be changeable for the projects.
   4) Technical assistance will be extended with in depth participation of manufacturer and engineers.

2. Finance Source of CFR
   1) ODA (Grant and Loan) will be extended to RGC as CFR capital.
   2) A capital contribution from RGC is also expected. Local proceeds of KR and KR2 might be a good potential resource for CFR or the contribution.
   3) Any grant given to a project is deemed as capital invested by CFR.

3. Total Amount of CFR
   1) The capital cost needed for electrification (52MW) for 3000 households that are suitable for electrification by biomass, amounts to about $100 million.
   2) Construction divided into 3 phases is proposed and the capital cost borne at the 1st phase for 1,000 households is estimated at some $33 million.

4. Structure
   1) A Policy Committee, which will be organized by the representatives of MIME, MEF and other related ministries and government entities, will decide all the policy issues and nominate the CFR manager.
   2) The CFR manager, who is expected to be appointed from a private company, will be assigned on a contract basis and will undertake, i) financial/accounting management of the CFR and ii) provision of technical services to the project implementation agencies.

5. Legal Status
   1) The CFR is to be established in MEF.
   2) MIME is responsible for the CFR operational risk.

6. Conceptual Figure (shown below)

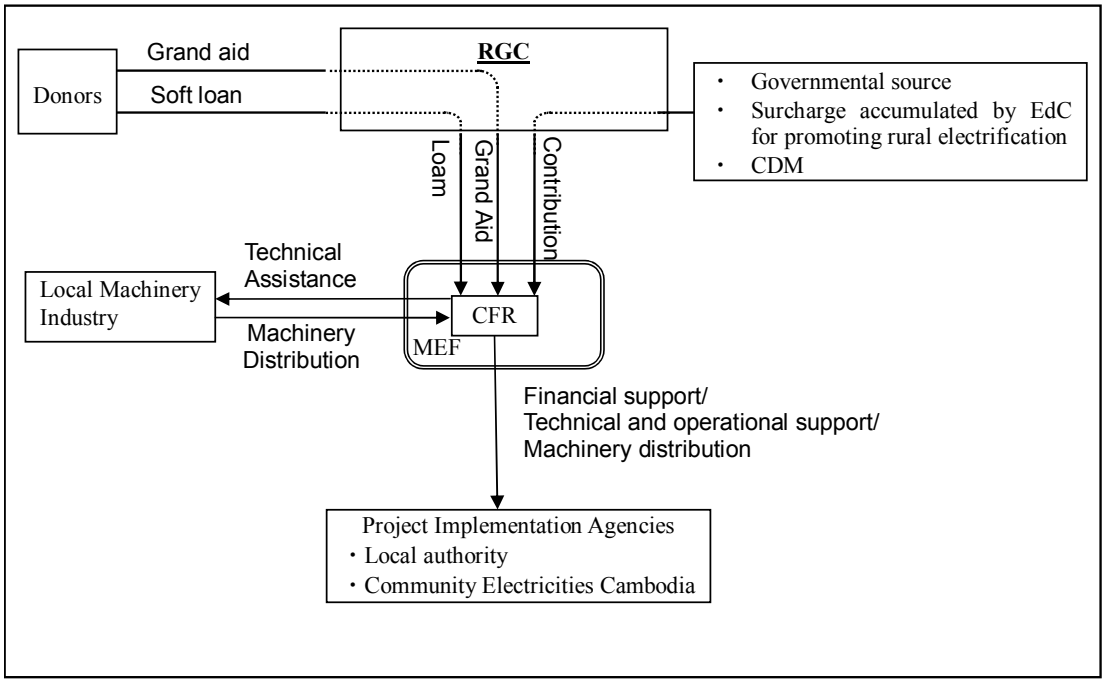


Table A-4 Comparative Finance Schemes of TSL and CFR

	TSL	CFR
1 Expected Finance Source	ODA Loan to RGC	ODA Grant and Loan to RGC
2 Means of Finance for Projects: ・ Finance ・ Lender ・ Interest rate ・ Risk taker	・Loan（grant from MEF) ・Banks ・Market rate ・Banks	・ Grant & loan ・ CFR ・ Preferential rate ・ MEF
3 Expected Agency for Project Implementation	REF, CEC	REF, CEC
4 Relations with REF	Grant from REF Loan from banks	REF and CFR share their work by area and energy source.
5 Energy Resources	REF takes mainly SHS and partly small hydro, diesel and biomass.	CFR takes mainly biomass and other renewable energy.
6 Others Implementation ability of villages (CEC)		CFR will examine this through pilot projects.

Note:
1 TSL is a Two Step Loan
2 Proposed renewable energy rural electrification program is based on proposed Grid Extension Program. Therefore its validity is subject to changes of the Grid Extension Program.
3 CFR and REF must operate with agreed close collaboration.

ATTACHMENT-11 RENEWABLE ENERGY POTENTIAL AS SOURCES OF DECENTRALIZED POWER SYSTEMS

No.	Characteristics of Potential
1.	**Micro-Hydro** (mini-grids) ■ The micro-hydro potential in Cambodia is limited to the mountainous and hilly areas. There is no such potential in the plain areas. There are potential sites that have no villages nearby to electrify. ■ Villages in the mountainous and hilly areas are sparsely distributed and village sizes are also small. As a result, there are potential sites that do not have sufficient demand for full development of the potential. ■ There are villages that have sufficient potential nearby but lack ability to pay. It is judged that such villages be first electrified with a solar BCS. ■ There are sites where head and rainy season river flow exist but they cannot meet the demand in the dry season because of sharp drops in the river flow and power output towards the end of the dry season. ■ Except for Mondol Kiri Province, etc., those rivers running in the hilly region have gentle river slopes. As a result, the required waterway is very long and the construction cost increases in order to develop the potential head available there. ■ As a result of the above, the micro-hydro potential sites suitable as sources of decentralized mini-grids are limited.
2.	**Solar Power** (BCS, SHS) ■ Abundant throughout the country (average of minimum monthly irradiation is 4.7 kWh/m^2/day)
3.	**Wind Power** (BCS, SHS) ■ The average wind speed 20 m above the ground is 2.6 m/s. The wind potential in Cambodia is low and limited only to local wind corridors.
4.	**Biomass Gasification Power** (mini-grids) ■ Being blessed with solar irradiation, rainfall, and land resources, biomass resources are abundant throughout the county and there is farming potential for biomass as well. ■ When biomass is cultivated by farmers under contracts with CECs as recommended in the Master Plan, the biomass power plant can be placed anywhere near a demand center. The potential is not site specific. ■ The fuel trees can be harvested from one year after transplanting and thereafter every 4-6 months. Therefore, the trees can be grown in parallel with procurement and installation of generating equipment and distribution facilities that also take about a 1 year period.

ATTACHMENT-12 COMPARISON OF ENERGY SOURCE CANDIDATES FOR MINI-GRIDS

No.	Items	Micro-Hydro	Diesel Power	Biomass Gasification Power
1.	Potential	Limited to the mountain and hilly areas	Anywhere applicable (Road for fuel transportation necessary)	Possible to cultivate all over the country except in the city and in areas submerged for a long time in the rainy season.
2.	Technical aspects: Technology maturity	Proven technology	Proven technology	As a whole, the biomass gasification technology is recognized to be at the entrance to commercialization after passing the demonstration stage. Some small scale downdraft gasifiers, often referred to as WWII, use a proven technology with over 1 million applications for automobile fuel. Small downdraft gasifiers are at a commercial stage in India (mainly woody biomass for power generation), China (mainly rice husks for thermal applications), and Myanmar (mainly rice husks for engines and generators).
	2ϕ A.C.	Possible	Possible	Possible
	24-hr operation	Possible	Possible	Difficult (possible by alternate operation of 2 units)
	Output stability	High	High	Some changes observed in frequency[16]
	Automatic operation	Technically possible (however, operator should be stationed to clear drifting wood and tree leaves from trashracks at intake, for operation logging, and for station guarding).	Possible (start and stop by manual operation in small units)	Not applicable to small units for rural electrification. Operator must standby at the station for tree chopping, loading to gasifier, monitoring of frequency, and so forth.
	Safety	High	Risk of accident (CO poisoning, fire)	Risk of accident (CO poisoning, fire, ignition and explosion of producer gas)

[16] According to an observation at the existing Anlong Ta Mey Village in September 2005, the frequency was mostly stable within about +1Hz but sometimes it dropped by about 5Hz. However, the frequency is strictly controlled for management of large power stations under a large power grid, and its fluctuation is unlikely to affect performance and safety of electric appliances used at home. In the case of rural electrification, voltage drops are of major concern. In the Aonlong Ta Mey village scheme, the voltage was stable at 400 V at the generator end. Since the distribution lines were designed and erected with support from an experienced NGO (SMEC), there have been no unacceptable voltage drops except black outs due to overloading.

No.	Items	Micro-Hydro	Diesel Power	Biomass Gasification Power
	Commercial supply	Many manufacturers exist worldwide.	Many manufacturers exist worldwide.	WWII type gasifiers are difficult to scale up. As of 2005, there are a few manufacturers commercially producing gasifiers. Also commercially sold in China and Myanmar but designed for rice husks. Gasifiers of developed countries are automated and clean. However, from the viewpoints of price and maintenance technology available, they would be difficult to introduce for rural electrification in developing countries. Although Asian products are not fully automated, these contribute to creating job opportunities and to make maintenance work simpler.
	Environmental impact	It is necessary to release a certain river flow for maintenance of the river ecology in the river section from the intake down to the outflow point of the power station.	Emission of CO_2	It is necessary to prohibit buying fuel from the local fuel wood markets, in order to avoid pressure to illegally cut forest resources.
	Issues	In general the smaller scale, the higher kW construction cost. It is difficult for CEC to assess potential and make a development plan.	There is a risk of price hike following the demand-supply balance in the world oil market and of shortage of supply.	The condensates from gas cleaner contains tar and phenol that has disinfecting effect (having acute toxity of medium extent). Accordingly, method of their final disposal is an issue. The exhaust gas from engine contains unburnt CO. (Siting of gasifier apart from residential houses, well ventilation of station house, and gas detector are required.)
3.	Construction costs of generating facilities	Generating facilities $4,000/kW	Generating facilities $500/kW	Generating facilities $1,300-5,000/kW In the EU, Euro3,000/kW for 10 MW class, and Euro6,000/kW for MW class
	Initial capital investment[17]	$1,229 per household	$424 per household	$592 per household (in the case of products from a manufacturer "A" in India)
	Unit electricity cost[18] ($/kWh)			
	at P.F. 15%	0.85	0.59	0.56
	at P.F. 30%	0.40	0.40	0.28
	Fuel cost	nil	$0.23/kWh	$0.03/kWh (nil as a community since fuel costs will remain within the community)

[17] Including costs for design, construction guidance, support to CEC, administration costs, and contingency.
[18] At consumer end including taxes.

No.	Items	Micro-Hydro	Diesel Power	Biomass Gasification Power
4.	Implementation period	2-3 years	1 year (distribution lines)	1 -2 years (gasifier, distribution lines, and fuel tree farming)
5.	Lifetime of generating equipment	20 years (depending on the water quality and specs, 10-30 years, generators for 30 years)	5-10 years for engine depending on design specifications	About 10 years for gasifiers[19], 5-10 years for engine, depending on design specifications
6.	Possibility of planning and design by CEC	Difficult for CEC to undertake planning and design	Possible (difficult for distribution lines)	Basic planning may be possible with Visual Guide prepared as part of the Master Plan. However, basic design is difficult.
	Implementation	CEC can provide labour force for construction works.	CEC can provide labour force for construction works.	CEC can provide labour force for construction works.
	Management	Operation and management of electricity business are possible. However, periodical inspection and maintenance work are difficult.	Operation and management of electricity business are possible. However, periodical inspection and maintenance work are difficult.	Operation and management of electricity business are possible. However, periodical inspection and maintenance work are difficult. (In the case of product of A company, technology required for operation and maintenance of the gasifier is at a similar level to that of a diesel engine.)
7.	Possibility of installing additional unit with demand increase	Difficult (not possible when all the potential has been fully developed.)	Easy	Easy (It will be necessary to have land for farming additional fuel trees. Since there are many farmers who wish to grow fuel trees, no specific difficulty is foreseen in fuel supply.)

[19] In the case of a company, it will be necessary to replace some parts that are exposed to high temperature every 3,000 hours of operation.

ATTACHMENT-13 ISSUES TO BE EXAMINED THROUGH BIOMASS PILOT PROJECTS

No.	Issues	Remarks
1.	Operation and maintenance by CEC	■ Monitoring if fuel tree farming is ongoing as planned; ■ Monitoring if power generation is achieved as designed; ■ Monitoring if the safety procedures for operation are observed; ■ Measurement of gas concentration in the station house, monitoring safety aspects such as pre-ventilation of gas piping system before igniting gasifier, etc.
2.	Management of electricity business by CEC	■ Training and monitoring meter reading, billing, tariff collection, accounting, deposit of surplus money, management of reserved fund of CEC
3.	Treatment of wastewater from gasifier	■ Testing if natural decomposition of tar (organic matter) by soil bacteria is dependable, or if another option, such as drying condensates to re-burn in the gasifier, is needed
4.	Operation and maintenance of gasifier	■ If operator can undertake operation and maintenance work as required; ■ If the ratio of forced outage is within a tolerable extent; ■ Monthly hours required for maintenance work.

ATTACHMENT-14 ADVANTAGES AND ISSUES ON TECHNICAL AND SOCIAL ASPECTS OF BIOMASS GASIFICATION POWER

Item	Advantages	Issues	Countermeasures
Technical Aspects			
1. Adequacy and economic efficiency as the power source of mini-grids	■ Appropriate to the dispersed power system from the point of procurement of biomass Basically cogeneration in northern Europe ■ The cost of power generation is lower than for other sources for mini-grid (lower than diesel in cases where the generation is greater than the amount equal to three-hour operation with full power in a day). ■ Effective use of local resources (creation of employment and income source, the fuel cost stays in the area, saving of foreign currency, cut down of emission of CO_2) ■ There are application results for rural electrification in India, Myanmar, China and Sri Lanka. The oldest one was installed in 1997 in India. Two sets have already been installed in Cambodia.	■ In the case of using 100% of producer gas (gas produced from biomass), high saving of fuel cost, but slow response to the load In the case of using a dual fuel engine, quick response to the load, but the oil cost is higher than 100% producer gas Safety measure ■ Measures to deal with power failure ■ Addition of a generator	■ The electrical equipment for use is limited to light load items such as lighting and TV in the mini-grid of electrification at level two. (There is the risk that the rich households may use high load equipment such as electric pots and clothes irons. -> Getting agreement with the applicant at enrolment, REE/CEC explaining in the village meeting in the planning stage. Basically any load beyond the current determined in the contract should be stopped by the circuit breaker box. However, such a low current circuit breaker is not available because of the small capacity permitted.) It is difficult to establish a habit of switching on/off when the mini-grid has an hourly power supply. Enlightenment is required, because the load of starting the generator can be reduced by switching items off when they go to bed. Regarding the large systems of more than 100 kW, it is supposed to be possible to use electro thermal products to execute any of the following measures. Accordingly, demonstration in the pilot project is required. 1. Application of a fly wheel 2. Installation of a gas holder (this is not recommended for the off-grid rural electrification, because a compressor and pressure tank are required.) 3. Hybrid with quick responding micro-hydro power (Samlout project falls into this category. It is recommended.) ■ Bearing with a kerosene lamp until repair completion (emergency power supply limited to lighting may be possible in the case of using some generators. However, an information supplement and the cooperation of users are required.)

Item	Advantages	Issues	Countermeasures
		for the demand increase and expansion of the target area for power supply ■ Still validation phase for middle to large scale generator (MW class) on a global scale	■ With a large scale mini-grid covering some communes it is easy to add generators, because a number of generators are operated in parallel and 22 kV of distribution line has already been installed. The spare power can be shared by a large scale mini-grid and a reduction of total cost and improvement of the stability of power supply can be tried. ■ The main target is the class of less than 100 kW that has a lot of actual performance in India and other places (not recommended for the small class of less than 10 kW).
2. Fuel supply			
1) Fuel wood cultivation type (REE / CBO makes a contract with the farmers on cultivation, supply and procurement)	■ Stable supply ■ Additional income to farmers (cash income approximately $40/year per cultivation of 0.2ha) ■ Avoidance of the pressure for illegal deforestation of existing forest (procure only the cultivated wood) ■ No competition with the other fuel demands, such as for cooking ■ Possible to supply for other purposes such as fuel for cooking or livestock food ■ Mainly legume woods that fix nitrogen and improve the soil nutrient as a manure wood when they are planted. They are considered as fuel wood. They improve the eco-sustainability in	■ Securing of land and farmers for cultivation ■ Technology for raising of seeds and seedling transplantation ■ Harvesting and power generation can be started after only one year from the beginning of cultivation ■ Crop yields increase with growth and decrease later on. The crop yields depend on the land condition, rainfall and vary every year. Who takes the risk of the imbalance between demand and supply of the fuel wood	■ Explanation and recruitment in the commune meeting (this is the base condition of the biomass power project and the postulate for the application of assistance) ■ There are actual achievements from cultivation other than power generation as demonstrated in the multi purpose plantations in Cambodia and Nepal. Instruction and assistance by CFR/NGO are required. (CFR has the function of TA.) ■ Planting when the electrification plan is fixed makes the cultivation in time with the schedule because it takes approximately one year to purchase the equipment, such as the generator, and construct the distribution lines. ■ Preparation of the cultivation plan anticipating spare power A crop yield of 10 t/ha is standard. It should be adjusted in accordance with the soil conditions. The cultivation plan should include an allowance for droughts. REE/CEC will stock it in warehouses for a short period. All villagers cultivate spare fuel wood in the house, on the edge of the road and on the boundary of fields

Item	Advantages	Issues	Countermeasures
	the cultivated area as agroforestry. ■ Plantations of fuel woods on the slopes and germination renewal contribute to prevent erosion of the surface soil. They also help to manage the water resources in the catchment area (prevention of flood).	■ Soil degradation by excessive harvest ■ Transportation ■ The risk of land occupation and the appearance of having exclusive suppliers ■ Illegal harvesting of the fuel wood and selling in the city Arson and harassment from envious people.	(retention of an energy reserve - possessing a standing crop and cutting it when required - they will grow up to large trees in six years.) ■ Although trees that fix nitrogen generally improve the nutrition condition of the soil, an excessive plantation may have bad effect on the soil. Instruction for sustainable management is necessary. ■ The power station should be located near the plantation. ■ Problems relating to land acquisition happen frequently in Cambodia because of the incomplete law. Accordingly, only the resident farmers of the CEC are targeted for the cultivation contracts. Absent landowners are left out of the target of potential contractors. (In the large scale plan for 1,000 households, the required land area is 20 ha and the annual income is to the extent of $3,600. Accordingly the advantage for a large landowner to supply exclusively with the risk of taking the social criticism is small. Even if the land was occupied, the CEC has no obligation to purchase the fuel wood from the absent landowner. However, it is supposed that a large landowner may put the pressure on them having some stake in the village. To cope with this, the followings should be mentioned in the regulation. - The contracts are limited to resident members. - The upper limit for the supply for each contract should be specified. These will help to exclude unwanted pressure. The DIME/NGO that supports the target community should monitor the situation.) ■ Illegal cultivation is difficult to counter. It is recommended that priority for cultivation contracts be given to poor households. The poorer the households are, the less information and knowledge they have. Therefore, enlightenment is important. Do not leave the enlightenment activities to the influential people (CDC members) in the village, but ask for the cooperation of the DIME,

Item	Advantages	Issues	Countermeasures
			NGO, Seila commune adviser and so on, who have the knowledge of the target area. The service area should be expanded as wide as possible. Try to expand beneficiaries by the establishment of a BCS and the supply of a charging service.
2) Agricultural residue (eg rice husks, rubber plants, cores of mice, peanut shells, stems of cassava, coconut shells)	■ Low price Rice husks were applied in Myanmar	■ Difficult to guarantee a stable supply of fuel Risk of competition with the existing demand ■ A large warehouse is required because of the seasonal emission (required stock is for 10 months, rice husk is produced approximately 10 months per year.) ■ Transportation	■ To apply agricultural residue as the fuel only in cases where it does not compete with the existing users and a stable supply is expected. ■ To construct a warehouse with a roof, a wall for wind and rain prevention and a ditch. Distributed storage at the farmhouse of the emission source ■ To construct the powerhouse near the emission source
3) Other alternatives for the procurement of fuel ■ Cutting the nearby trees		■ The risk of encouraging illegal logging	■ The implementation depends on management by the community. However, this is not recommended at this moment, because the risk is large. (This method is applied in combination in India.)
■ Purchase in the market	■ No effort for cultivation	■ The risk of price increase and illegal logging	■ Difficult to avoid price increases because of the bulk buying Not recommended because this encourages the pressure for illegal logging.
3. Maintenance	■ Equivalent to the technology for the maintenance of a diesel generator	■ Reliability of the electricity meter ■ Daily cleaning of the filter and maintenance of the engine ■ Fostering of mechanics	■ Government (MIME, REF etc.) should bulk purchase and lease the electricity meters. EdC has the testing equipment in each province. ■ Installation of a gasifier with the function for high purification of gas (not available for small equipment -> target more than 200 households) ■ Selecting the candidates for operator and training them in the rice mill, etc. (technical assistance from EdC, CFR and NGO is required.)

Item	Advantages	Issues	Countermeasures
		■ Parts replacements for the gasifier are required per 3,000 hours of operation in the case of products from "A" company in India. ■ Purchase of spare parts	■ Initial training by the maker and assistance from NGOs (an engineer from SMEC can be a substitute) ■ Purchase through the agency of the maker Fostering of domestic enterprises and price decrease by the licenced production of gasifiers - domestic procurement of the engine and the formulation of a system with a flywheel, etc. is the issue.
Social Aspects 4. Organization for implementation and operation			
1) In cases where REE implements and operates the project Application of the public offering method	■ Only the villagers wishing to make an electricity contract, pay the initial connecting charge and monthly electricity charge. No community activity that needs time and patience is required.	■ The electricity charge becomes high. The following items make the charge high. - Fund procurement cost - Labour fee REE pays - The risk of inauguration - The risk of price escalation - Cost for fund procurement - The risk of late payment - The profit ■ It is important to make a contract with a reliable REE contractor. (Even the REEs in major cities are mostly micro enterprises and their distribution facilities are often poor.) ■ The risk of bankruptcy and escape of REE contractors and the risk of inauguration ■ The idea to decrease the construction cost by supplying villagers labor	■ The subsidy by CFR, a loan with low interest, provision of technical instruction Applicable to the villages that have the ability to pay (three dollars fifty cents per month is required with the assumption of more than 50% ownership rate of batteries, with a unit cost of $0.50/kWh and a consumption of 7 kWh/month.) ■ Having EAC or REE association introduce the contractor with proven experience. The villagers negotiate a contract with the REE after confirmation that the electricity charge will be standard with the existing diesel mini-grid facility. ■ The villagers do not pay the initial connecting charge before the completion of the facilities. Accordingly, they can get around the actual loss. ■ Releasing the cash for construction costs at the initial stage or including the cost in the monthly charge

Item	Advantages	Issues	Countermeasures
		to the contractor of the REE is difficult to arrange.	(There is the actual example of the village road construction. However, the villagers cannot understand why they have to undertake the contractor's work and do not have any incentive to work. Accordingly, this will not function well. A contract that makes the contractor use the supplied labor seems to include the source of this problem.)
2) In cases where the CEC implements and operates the project directly.	■ Electricity charge can be lower. (Labour supply to the construction, CBO bears the risk of payment delay, profit not necessary, etc.) ■ Internal deposit for equipment renewal can be the source of micro credit (deposit to REF is also an alternative). ■ It is possible to buy the electricity from EdC after connection to the grid. (It is required that the generator should be installed in parallel with the high reliability generators in the more than 100 kW class. The generation cost should be decreased below the standard of EdC.)	■ All works listed below to be managed by the villagers • Establishment of CBO • Registration to MOI • Preparation of electrification plan • Getting the investment permission from DIME • Deposit of self fund • Preparation of application documents for assistance • Purchase of the equipment for electricity distribution and generator (a contract with the supplier is available as well.) • Construction • Procurement of fuels • Getting the permission of REE from EAC • Operation and maintenance • Collection of electricity charge • Accounting Taking account of the actual	■ DIME will enlighten and supply the information to the villagers using the Visual Guide that the Study Team has prepared and this will be distributed to all communes. (CFR will give the subsidy for this activity to the villagers through the CEC) Instruction for the establishment, technology and operation, and monitoring by CFR/NGO (the remuneration will be paid to the NGO from the CFR subsidy for TA). Demonstration by the implementation and operation of the pilot project will allow consideration of the settlement plan for the issues beyond the assumption Standardization of more than 200 households per project (Small scale mini-grids are difficult to maintain in the technical, cost and operational aspects.) The plan that covers some communes by a large-scale mini-grid and a lot of CEC/REE buy the electricity from the mini-grid and take charge of just retailing is favourable (such as the Samlout project). Risk diversification It is desirable that the large-scale mini-grid and the micro-hydro power station should be constructed by grant as a PPP project, and the operation should be delegated to RPC. The CEC should establish the association for retailing.

Item	Advantages	Issues	Countermeasures
		situation of villages in Cambodia, having only the technical assistance of REF/Biomass NGO is not sufficient. Establishment of a cooperative relationship with the NGO that assists the community activity and the specialists is the issue.	■ The existing Anlong Ta Mei project deposits funds to Acleda Bank.
		■ Management and keeping of the resource for the loan repayment and the deposit for equipment renewal (the risk of bankruptcy of the bank, non-productive cabinet savings)	■ It is desirable that the fund should be contributed from the domestic re-distribution of the grant fund by REF/CFR as a mutual subsidy from grid users. The Study Team proposes this fund to be used for the activity of MIME/DIME supporting CECs.
		■ The electricity charge in cases of the construction by a grant	■ For example, measures such as a supply stop in cases of one-month payment delay are required. A grace period of more than six months is applied in the Siem Riep project, because the farmer's income is limited to the harvest season. (If the monthly consumption is lower than 1 kWh, the payment is $0.50. This is lower than the cost of a battery. The preparation of the initial fund is the issue. This may be settled if the CEC accepts the supply of labour for all charges for the poor families.)
		■ The risk of the non-payment and payment delay because of there being no regular cash income	■ The consumption of 100 W/HHs on average is standardized. (The supply equipment is 130 W/HHs including the power for houses, the distribution loss, and the surplus power)
		■ The possibility of the lack of surplus power and power failure because of the under estimation of the demand	(A supply surplus of 30%, and multiple installation of generators is a base.) The supply power should be set within the range from 30W to 200W depending on the income level of the household. The desirable power amount and estimated charge for each household should be confirmed in the planning stage and participating contracts prepared. An extra generator for a large or wide mini-grid is easy to be added.

Item	Advantages	Issues	Countermeasures
		■ Lack of income because of the excessive demand estimation	Notice on electricity usage: The enlightenment of the villagers is necessary regarding the safety, the recommended lighting equipment and the capacity etc. by explanation material and posters. ■ The lack of income will have a significant effect on the funding plan of an electrification project. CFR should check the demand forecast at the screening of the application for assistance. In cases where the forecast is excessive, CFR should request the CEC to review it.
5. Electrification area	■ Package electrification is possible in cases where the households are located continuously along the road or the distance between the villages is small. ■ The electrification of the middle area between PAGEs or the area with no chance of future grid extension is possible (fuel transportation is not required.) ■ Even in the PAGE, early electrification to avoid waiting for grid extension for a long time is possible depending on the villagers' will and cost sharing.	■ Small villages far from the commune center and dispersed households more than 1 km from a distribution line are difficult to be electrified. (The costs for extension of a distribution line are relatively high in cases where 50 households are far more than 1 km from the commune center.) The relatively rich families along the road in the commune should be electrified with priority. There is a high possibility for the poor families to not be able to participate in the mini-grid electrification. ■ The poor households can not participate in the CEC. ■ An initial connection charge cannot be prepared.	■ The poor households should be considered by planning at the initial stage to supply a battery charging service by installing a BCS powered by the mini-grid. (an explanation is required for the villagers who receive the electricity from the mini-grid that the increase of the daytime power consumption results in a decrease of the electricity charge.) ■ It is favourable that payment by labour should be admitted to the low consumption households lower than 1 kWh per month. The agreement of the other members is the key. ■ In cases of CECs, the amount of subsidy and loan are decided by adding the initial connection charge to the construction charge in this MP. In the case of REEs, the initial connection charge is covered by the CFR subsidy, utilization of micro credit and mutual support in the villages. The utilization of electricity will be started when the payment is completed.

Item	Advantages	Issues	Countermeasures
6. Development of the local social economy as a result of the biomass power project	■ For the households whose monthly expense is under $10 per month, the cultivation and supply of fuel woods up to 2 t in 0.2 ha can cover their electricity charge. ■ A household using electricity at 10 kWh per month consumes the equivalent of 180 kg of fuel. It costs $3.60 per year. The electrification project for 500 households returns $1,800 to the commune per year. ■ The electricity by mini-grid can be used, not only for night lighting, but also for other demands such as handicraft industry and pumps for water supply. ■ Provision of equal opportunity for electrification to the area far from the grid system and with no micro-hydro potential (Social justice) ■ The opportunity for confirmation of the mutual cooperation by community members. ■ Promotion of electrification as a result of the small size of the fund required for electrification	■ The number of farm houses that can make contracts for fuel wood cultivation is limited. (Fuel consumption of a household is approximately 0.2 t per year. One out of 10 households receiving electricity can manage the electricity charge by himself.) ■ The lowering of generation cost by the daytime demand ■ Many communities need assistance such as having a handicraft industry promotion plan.	■ It is desirable that the poor households should make contracts with priority in case there are a lot of applicants for cultivation. (The priority should be judged in accordance with the capacity for payment of the initial connection charge and electricity charge. Taking precedence over the fuel supply and purchase from the beginning of generation will contribute to the resource of the initial connection charge of the poor households who cannot manage the fund even if they hope to join.) In the case that all households cultivate fuel wood, the monthly income per household reaches 30 cents that is the fuel charge for a household. In the case where one in 10 households cultivates, the income reaches $3 per month. This can be applied to the electricity charge. ■ The more the electricity is used, the lower the generation cost becomes as a feature of biomass power generation. For example, demand boosting by charge preference (lower charge) to the consumers of large quantities, more than 10 kWh per month (large income with the same generators through long time use) However, early replacement of the heatproof parts of the gasifier is required because the total operation hours accumulate more quickly (the standard is 3,000 hours for replacement with the equipment made in India.) The engine life will also finish earlier. In cases where there are demands such as BCS, water supply pump, rice mill, ice plant, carpentry shop and other handicraft industries, they should be included in the electrification plan from initial stage. ■ Studies such as for the promotion of production activities or water supply pumps for the cultivation of small scale cash crops are difficult for the target community to conduct on its own.

Item	Advantages	Issues	Countermeasures
	■ Contribution to the reduction of poverty (MDG : reduction of poverty, improvement of health and education, environmental protection)	■ There is the electrification demand in the healthcare and education sectors. However the electricity charge is the issue.	How to utilize the human and water resources, tourism potential and agricultural products should be discussed in the stakeholder meeting at the electrification planning stage. The members of the stakeholder meeting should include CDC, Seila program, specialists in agriculture, tourism and handicraft. The assistance plan for each stakeholder should be prepared jointly, led by the CDC (Commune Development Council). One of the positive impacts of the electrification is the access to information by radio and TV. As a result, basic knowledge can be gained. Although the utilization of electricity for Karaoke and video is expected in many communities, enlightenment is required on how to use the electricity to best advantage. The expectation for electrification is as strong as for roads, healthcare and education, because it distributes benefits to each household directly. It is important to promote information sharing and participation of a lot of villagers thorough small-scale meetings to avoid information concentrating on the rich people. ■ The people in charge of healthcare, education, environment protection and community forest activity etc. in each area should be involved in the CEC as stakeholders at early stage. Their cooperation and opinions should be reflected in the project.

ATTACHMENT-15 ELECTRIFICATION AND POVERTY MITIGATION

- How does electrification of the off-grid areas by mini-grids contribute to poverty mitigation?

Direct effects of electric lighting

1) The electrification will provide a chance for children to get a high-paid job opportunity and contribute to improving the household income by having various ways of studying through night book reading at home, attending private English schools and having computer lessons at school.

2) The level of health and hygien services will be improved by providing electric lighting to health posts and maternity homes.

3) It will facilitate opening and operation of literacy schools for adults at night-times.

Effects on health and hygien aspects

4) It will become possible to have cold storage of vaccines for poisonous snakes etc. at health posts and first-aid will be able to be provided in case of accidents to the villagers.

Potential effects on poverty mitigation

5) The poor households can enjoy better and more electric lighting at a lower expense, compared to battery lighting, by joining a CEC, if the CEC accepts raising of the initial equity by such poor households in kind as a labour resource.

6) In the case of biomass gasification power, the income level of poor households can be improved by giving them priority contracts for farming fuel trees.

7) Sourcing of the operating surplus of the CEC for future replacement of equipment and providing micro-crediting services to poor households for improvement of their income.

8) Due to supply of daytime demand, the generation cost for the whole mini-grid will decrease, and household expense for lighting will relatively decrease. For poor households, it becomes possible to use much more lighting at a cheaper price for a longer time compared with battery lighting.

Effects on improvement of household income

9) Household incomes will be improved through dressmaking, wood carving, and so forth at night-times.

10) Incomes will be improved through higher efficiency of work and productivity by use of electric power for stone carving, wood carpentry, and so forth in the daytime.

11) The money previously spent on diesel fuel, which went out of the community, can be allocated to other economic activities within the community by substituting electric motors for diesel engines at water supply pumps, rice milling machines, and so forth.

12) When there is a means of transport such as trucks, boats and brokers up to the nearby markets, like in a provincial capital, cash crops may be grown with irrigation pumps powered by electricity to increase the household income.