2.2.7 Institution for Capacity Building

Significant capacity building is required for private developers (REEs and CECs) and government sector (MIME and EAC) for achieving the ambitious target of rural electrification master plan.

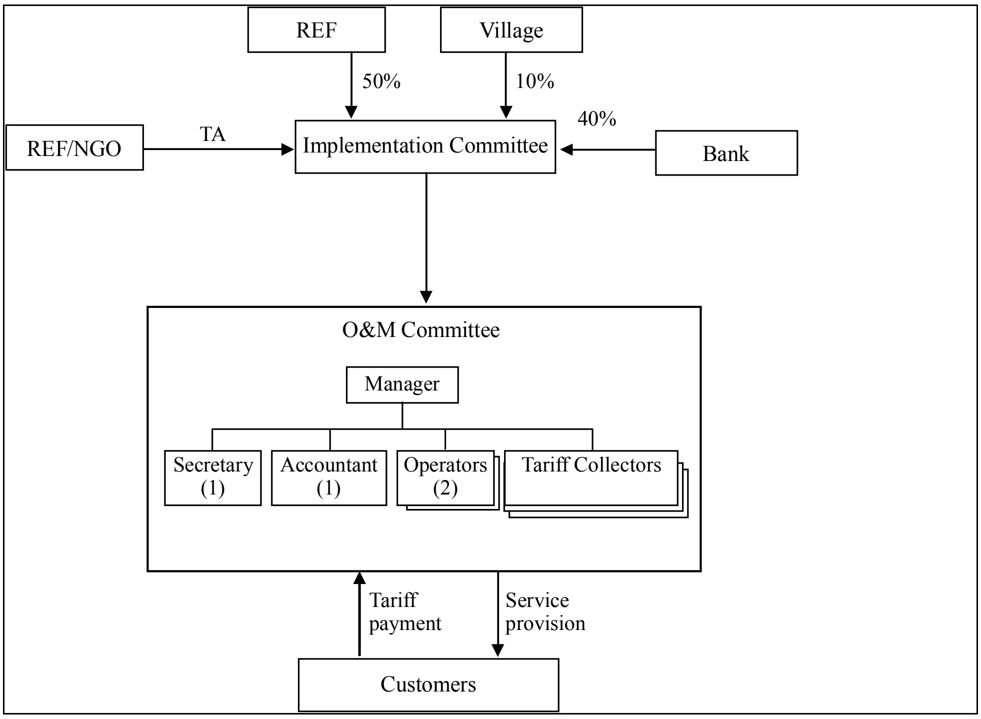
First, as discussed in Sub-section 2.2.5 of Part 1, the capacities and performances of most of REEs who are expected as the mainly player of rural electrification need to be greatly improved in technical, operational, financial and managerial aspects. MIME should coordinate with EdC to provide capacity-building and technical training programs for REEs and CECs involved in rural and renewable energy development. As proposed by the REAP, following areas are identified for capacity buildings:

- Technical training at the EdC training center in Phnom Penh
- Support for technical upgrading of existing mini-grid systems and household systems
- Assistance to support increased productive uses in villages serviced by mini-grids
- Selection, design and installation training for solar PV systems, micro-hydro systems, small diesel gensets and networks
- Procurement systems for equipment and facility
- Line technician training including fieldwork, electrical theory and electrical workshop training
- Safety training, first aid and resuscitation
- Vehicle maintenance
- Meter technician and meter reading training
- Residential and commercial wiring
- Billing and collection management
- Handling customer relations and complaints

EdC in coordination with MIME is responsible for the above technical training. In addition to the training courses, institutional capacity building activities should be provided by MIME for the private investors. Among the activities needed are:

- Extensive, private sector initiated, hands-on training in the subjects of renewable energy technology, business management and project financial analysis
- Extensive shared-cost exposure missions to regional countries to promote learning, the creation of business-to-business linkages and encourage regional partnerships and integration of best practices in the renewable energy sector
- Regional and national renewable energy workshops and trainings that promote decentralized rural electricity and economic development plans, local ownership of the rural and renewable electrification process and institution building in the form of business associations centered on promoting rural electrification through renewable energy technologies
- Public-sector led analysis and evaluation, skills training and government-donor, shared-funded regional exposure missions
- Reorganize and restructure public institutions so they are prepared to fulfill the roles and responsibilities necessary to develop and enabling business and investment environment.
- Mechanisms to promote learning and skills development that encourage privates and public sector participants. These mechanisms will enable continuing dialog, help define market needs and promote public sector services to assist and support the private sector in developing the renewable electricity market.

For CECs running the mini-grid systems, NGOs in addition to the RGC entities (MIME/REF, EAC and EdC) will be main facilitating partners to help the CECs organize them, locate the financial support, build capacity of implementing unit and O&M committee, including various training programs for staff of the O&M committee. An example of organization of CEC-owned mini-grid system under the support of NGO and RGC is shown in the following figure. It should be noted that training of paid-operators (usually civil and electrical technicians for mini-hydro systems) is imperative in order to secure O&M sustainability. In this respect, the operators need to receive an appropriate OJT program including training abroad where similar systems operated already.



Source: JICA Study Team

Figure 2.2.27 An Example of CEC Mini-grid Operation

Institutional strengthening of MIME, REF, EAC and EdC is vital for execution of the propose master plan program. The areas of capacity building needed are as follows:

- To design and implement the policy on deregulated and liberalized rural electrification sector development encouraging the private sector participation (REE and CEC)
- To clearly identify and define the risks and mitigation measures shared by the government and private sector entities
- To implement request for proposals, proposal evaluation, contract negotiation, contract management, performance monitoring of private entities
- To design and implement smart credit operation using ODA funding
- To delegate to and build capacities of local officials concerned to administer and manage electrification businesses on local basis

As discussed in Sub-section3.9.1 of Part 1, the WB's RE&T Project include the institutional development and sector reform technical assistance component (9 M$). This TA component comprises consulting and advisory services to: (i) **MIME** in renewable energy policy development, power market analysis, and development of a power master plan; (ii) **REF** for implementation support, promotion of rural income generation options, renewable energy business development, REE improvement and association building, and capacity building of financial institutions; (iii) **EAC** for institutional strengthening; and (iv) **EdC** for services of a project implementation consultant and in-house advisor, creation of an independent monitoring agency and a project grievance committee, improvement of commercial practices, management training, capacity building for land acquisition, rêsettlement and environment, and power investment planning.

2.2.8 Community Empowerment

The development of framework for support management and implementation of the community based project is crucial for sustainability. Prior to implementation, issues that relate to the establishment, operation and maintenance of the proposed electrification must be closely studied. Several major concerns are enumerated below:

- The degree and manner of participation by stakeholders - including the village / commune development committee, the local populations, businessmen and entrepreneurs in the locality, NGOs, and local governments - should be clearly defined
- Process of implementation – who or what will facilitate the process of raising awareness about the project, creation of relevant structures, roles and responsibilities of various stakeholders.
- Structure and needs of organization that will operate and maintain the project – what are the needs that must be addressed so that capacity to operate and maintain will be developed in each project site.

The socio-economic surveys revealed that most rural households except for the poorest groups have strong desire for electricity, thus, are able to pay for power tariff (at least for consumption for lighting and basic home appliances) to certain portion for their budget. However, their financial base has to be improved in order for them to be able to continuously access to the service, and even use more electricity for productive activities in the future when the 24-hour continuous grid-quality electricity is available.

Strengthening of economic base of rural households calls for existing and alternative livelihoods be further developed and diversified. However, development of livelihood options is not easy task, in case that a large part of household expenditure has been already spent to routine kinds of expense (such as food, education, health, and energy). In this relation, so-called "demand-oriented" approaches will be important, in order for sustainable performance. The specific needs of end-users will be assessed and utilized for the design stage as well as monitoring and evaluation. If the poor cannot access the electricity due to the high cost of initial costs, the planners need to attempt to provide micro-finance schemes for lending the connection fees or to mobilize external funds for providing the subsidies.

Micro financing is generally available in the rural population in Cambodia, but largely through informal money-lender and family / relative network. These informal sources usually finance routine expenses such as buying foods and materials for small business, but requires very high interest rate (about 50% or more per annum) and short repayment periods (1 ~ 3 years). There are only a few formal financial institutions in rural areas that lend to the population for productive purpose, and little public support to promote income generation activities.

The proposed community empowerment activities include provision of micro financing to help poor customers afford the high initial costs of obtaining electricity connections or for purchasing batteries and to promote income generating activities of electricity.

The rural electrification program should be closely coordinated with the RGC's rural development plans such as the Seila program to ensure that electricity will support regional economic development and be available to meet education, health care, household services.

The WB's RE&T Project includes a subcomponent for rural income generation promotion in its TA component. This TA will be provided to develop end-use activities in order to increase income generation opportunities in rural areas and enhance productive uses of electricity. Suitably tailored training programs and demonstration activities on new electricity-based rural income generating options as well as adapting existing uses to run on electricity will be offered (for example, use of power tools by existing village carpenters.) Promotion of such village economic activities will gradually build up demand among new consumers and also increase affordability. It is envisaged that these activities will be carried out by NGOs and local consultants so as to ensure outreach to rural consumers. Specific areas of support include: (i) rural village and commune planning for electrification, preferably accompanied with establishment of electrification committees (ii) assessment of potential productive use of electricity (iii) sound operation of electrification with training programs and demonstrations; (iv) establishing links between rural businesses and markets.

2.2.9 MP Projects

Electrification plans of villages by micro hydro, biomass, and solar BCS are presented in Tables 2.2.21 to 2.2.23. Since these are very voluminous, only the top group and the last group with summary are shown for each energy group as sample. Full lists are available on the server of JICA Study Team.

Table 2.2.21 List of Mini-Grids by Micro Hydro

MHP Reference No.	ID No. of RE Scheme	Name of RE Scheme	Single or Multi-Village Scheme	Data to be Prepared by MH Team: Villages To be Electrified: Province	District	Commune Name	Village Name	ID No. by Seila	Micro Hydro: Potential Dry Season Power P_d	Micro Hydro: Length of MV Trans. Lines (km)	Data for Priority Ranking: 1 Maturity (A/R/S/N)	2 Dif-fusion level of battery (%)	3 Distance to pro-vincial capital (km)	5-1 Q & H measur-ed? (Y/N)	5-2 Length of new access road (km)	5-3 Cost per HH ($/hh)	5-4 Free from land-mine? (Y/N)	7 Any daytime demand? (Y/N)	8 Dif-fusion level of TV (%)	9 Any comm. acti or popular industry?	10 Nos. of house-holds	Data to be Referred to Seila Database and Calculated: To be Quoted from Seila: Data of Villages to be Electrified: Nos. of Total Households	11. Level of literacy	4. Plain Region or others?	Data to be Calculated: Nos. of HH to be Electri-fied	Total Demand incl. loss (kW)	Installed Capacity of MHP (kW)	Backup Capacity P_{mh} (kW)	Length of LV Lines (km)	Cost ($1,000): G.E.	Cost ($1,000): Back up	Cost ($1,000): MV & LV	Cost ($1,000): Total	Point for Priority Ranking Total	Rank and Remarks
8-12	MH1105-01	**O Moleng**	11	Mondul Kiri	Saen Monourom	Monourom	Daeum Sral	11050101	82	5.0	S	2.44	5	Y	0.2	580	Y	N	36.89	N	1,434	1,434	74	O	1147	149	82	15	17.2	190	8	291	665	**12.54**	B/D on going by Japanese Grant
8-13	MH1105-02	**O Romis**		Mondul Kiri	Saen Monourom	Monourom	Chrey Saen	11050102	19	1.5	S		7	Y	1.4		Y	N		N							19			74					
8-14	MH1105-03	**Prek Dak Deurr**		Mondul Kiri	Saen Monourom	Sokh Dom	Mean Leaph	11050201	33	9.0	S		9	Y	0.5		Y	N		N							33			103					
8-15	MH1105-04	**Prek Dak Deurr D/S**	11	Mondul Kiri	Saen Monourom	Sokh Dom	Daoh Kramom	11050202	206	4.5	S	2.44	13	Y	6.0	669	Y	N	36.89	N	1,434	1,434	74	O	1147	149	149	0	17.2	481	0	286	767	**11.81**	Superior site for succeeding project to the above Japanese Grant Scheme
10-2	MH1605-01	**O Katieng**	4	Ratanak Kiri	Lumphat	La Bang Muoy	Kam Phlenh	16050301	40	6.5	S	0.00	7.5	Y	0.5	808	Y	N	5.76	N	295	295	16	O	236	31	31	0	3.5	77	0	114	191	**8.92**	On going by UNIDO
1-2	HB0209-01	**Sangke D/S**	45	Battambang	Rotonak Mondol	Phlov Meas	Phlov Meas	2070301	59	115.0	S	0.44	50	Y	1.0	697	N	N	22.09	N	6,786	6,786	78	O	5429	706	59	562	81.4	649	843	2,290	3,781	**12.43**	**1**
1-3	HB0209-02	**Sangke U/S**		Battambang	Rotonak Mondol	Phlov Meas	Tuek Sab	2070303	*85*		S		76		3.0		Y										85								
1-2	HB0209-03	**Sangke D/S Alternative**	8	Battambang	Rotonak Mondol	Phlov Meas	Phlov Meas	2070301	59	13.0	S	1.81	50	Y	1.0	665.0	N	N	20.39	N	1,324	1,324	78	O	1059	138	59	79	15.9	233	119	353	704	**11.34**	**2**
10-10	MH1605-02	**Bay Srok**	3	Ratanak Kiri	Lumphat	Ka Laeng	Bay Srok	16050204	65	3.0	S	34.11	35	Y	0.0	587	Y	N	7.86	N	560	560	0	O	448	58	58	0	6.7	139	0	124	263	**10.62**	**3**
8-17	MH1104-01	**Bu Sra**	10	Mondul Kiri	Pech Chenda	Bu Sra	Phum Lekh Muoy	11040401	91	25.0	R	0.22	46	Y	11.0	1,201	Y	N	1.22	N	899	899	32	O	719	93	91	2	10.8	462	1	401	864	**10.18**	**4**
6-19	MH0908-01	**O Sla D/S**	4	Koh Kong	Kampong Seila	Kampong Seila	Cham Srei	9080201	283	15.0	N	0.40	175	N	15.0	904	Y	N	13.13	N	1,249	1,249	57	O	999	130	130	0	15.0	543	0	360	903	**8.50**	**5**
9-1	MH1506-02	**Xtung Tun Po**	3	Pursat	Veal Veaeng	Pramaoy	Stueng Thmei	15060403	55	11.0	N	0.00	120	N	1.0	849	N	N	14.63	N	451	451	50	O	361	47	47	0	5.4	121	0	186	307	**7.43**	**6**
5-9	HB0704-01	**Srae Cheng**	1	Kampot	Chum Kiri	Srae Chaeng	Pong Tuek	7040404	6	8.0	S	0.00	65	Y	10.0	818	N	N	26.76	N	284	284	66	P	227	30	6	24	3.4	22	36	128	186	**7.12**	**7**
6-12	MH0907-01	**Tatai D/S**	2	Koh Kong	Thma Bang	Ruessei Chrum	Trapeang Chheu Tr	9070403	62	10.0	S	0.00	60	Y	1.5	2,006	Y	N	13.55	N	155	155	83	O	124	16	16	0	1.9	122	0	127	249	**6.33**	**8**
1-1	MH0209-01	**Tributary Stung Cra Nhung**	14	Battambang	Samlout	Ta Taok	OU Nonoung	2090101	330	33.0	N	0.00	90	N	12.0	1,592	N	N	12.20	N	844	844	80	O	675	88	88	0	10.1	603	0	471	1,075	**5.35**	**9**
9-6	MH1504-01	**O Leach Meas**	2	Pursat	Phnum Kravanh	Samraong	Roveang	15040710	35	13.0	N	0.00	60	N	3.0	1,772	N	N	14.02	N	164	164	25	O	131	17	17	0	2.0	74	0	158	232	**4.66**	**10**
8-5	MH1101-01	**Prek So Long Lower**	5	Mondul Kiri	Kaev Seima	Srae Khtum	Srelovi	11010403	42	14.0	N	0.00	55	N	4.5	1,966	Y	N	4.55	N	286	286	40	O	229	30	30	0	3.4	263	0	188	450	**4.56**	**11**
2-3	MH0408-01	**Stung Thum**	1	Kampong Chhnan	Tuek Phos	Chieb	Kos Khtum	4080211	14	2.5	N	0.00	45	N	12.0	1,999	Y	N	16.82	N	107	107	62	O	86	11	11	0	1.3	129	0	43	172	**4.12**	**12**
5-1	MH1802-01	**Ou Treb Da**	1	Krong Preah Sihanouk	Prey Nob	Cheung Kou	Anlong Krapeu	18020407	165	8.0	N	0.00	60	N	19.0	6,927	Y	N	19.67	N	61	61	88	P	49	6	6	0	0.7	250	0	90	339	**-6.59**	**13**
6-35	HB0506-01	**Stung Sva Slab**	**4**	Kampong Speu	Phnum Sruoch	Chambak	Krang Chek	5060101	56	12.0	S	0.00	60	Y	9.0	619	Y	N	29.47	N	665	665	41	P	532	69	56	13	8.0	91	7	232	330		Extreme draw down of dry season discharge. Excluded from ranking.
14-1	MH1713-01	**Stung Siem Reap U/S**	**8**	Siem Reap	Svay Leu	Khnang Phnum	Ta Penh	17130301	73	23.0	S	0.00	50	Y	2.0	1,159	N	N	12.42	N	604	604	47	O	483	63	63	0	7.2	229	0	331	560		Separate study conducted by JICA. Relation with TL from Thailand. Excluded from ranking.
14-2	MH1703-02	**Stung Siem Reap D/S**	**19**	Siem Reap	Banteay Srei	Khnar Sanday	Banteay Srei	17030101	348	55.0	S	0.05	50	Y	2.0	655	N	N	29.48	N	3,697	3,697	66	O	2958	385	348	37	44.4	748	19	1,172	1,938		
								Total	2,149	374		40	1,139		115	25,808			317		19,975	18,541	904		14,833	2,078	1,425	653	240	5,368	913	6,989	13,270	107.98	
								Max	348	115		34	175		19	6,927			37		6,786	6,786	88		5,429	706	348	562	81	748	843	2,290	3,781	12.54	
								Min	6	2		0	5		0	580			1		61	61	0		49	6	6	0	1	22	0	43	172	-6.59	
								Mean	102	19		2	54		5	1,434			18		1,110	1,091	53		873	115	68	36	13	268	51	388	737	7.20	

Note : 1) "Total, Max, Min and Mean" in category of " Point for Priority Ranking" were calculated excluding the HB0506-01, MH1713-01 and MH1713-02, while "Total, Max, Min and Mean" in the other categories includs them.
2) "Total, Max, Min and Mean" in all categories were calculated without HB0209-03.

Source: JICA Study Team

Table 2.2.22 List of Mini-Grids by Biomass Gasification Power

Data to be Prepared by BG Team																Data to be Referred to Seila Database and Calculated															
			Villages To be Electrified						Data for Priority Ranking							To be Quated from Seila Database or 6 pro village survey				Data to be Quated from GIS				Data to be Calculated							
									1	3	6	7	9	10				8	11	2	4	5-5					Cost ($1,000)				
ID No. of RE Scheme	Name of RE Scheme	Single or Multi-Village Scheme	Province	District	Commune Name	Village Name	ID No. by Seila	Installed Capacity P_{bg}	Maturity (A/R/S/N)	Air distance to pro-vincial capital (km)	Renewabel Energy? (Y/N)	Daytime demand? (Y/N)	Any comm. acti or popular industry? (Y/N)	Total nos. of house-holds	Remarks on Daytime demand incl. BCS, Community activities, ATP	Village scale Nos. of Total House-holds	Nos. of HH to be Electri-fied	Diffusion level of TV by SEILA 2003(%)	Level of literacy	Diffusion level of battery (%)	Plain Region or others?	Per hh area of grass-land? >0.02 ha	Is agri waste suffi-cient? (Y/N)	Demand per hh incl. loss (kW)	Length of MV Lines (km)	Length of LV Lines (km)	G.E.	MV & LV	Total	Point for Priority Ranking Total	Rank
BG1504-02	Phnum Kravanh Bio	20	Pursat	Phnum Kravanh	Leach	Leach	15040201	408	S	27.00	Y	Y	N	3,927		3,927	3,142	19.61	80.53	0.00	O	0.52	N	408	*8.0*	47.1	612	739	1,351	13.37	1
BG0405-01	Svay Bakav CF	1	K. Chhnang	K. Tralach	Ta Ches	Svay Bakav	4050908	36	S	30.00	Y	N	Y	342	Community forest supported by Concern Worldwide.	342	274	56.43	69.11	0.35	O	0.49	N	36	0.5	4.1	54	62	116	11.63	2
BG0607-02	Kraya CF JICA	4	K. Thom	Santuk	Kraya	Kraya	6070501	112	S	54.00	Y	N	Y	1,072	Community forest supported by JICA CBFS	1,072	858	12.85	76.51	0.10	O	9.31	N	112	1.7	12.9	168	198	366	11.16	3
BG2110-01	Takeo CelAgrid	12	Takeo	Treang	Sanlung	Angk Ta Phouk	21101001	125	S	26.0	Y	N	N	1204	Supported by CelAgrid. There is a small mountain to be reforested.	1,204	963	34.78	83.82	0.00	P	0.35	N	125	1.9	14.4	188	221	408	10.89	4
BG0304-38	Krasang	1	Kampong Cham	Dambae	Tuek Chrov	Krasang	3040608	52	N	58.6	Y	N	N	499		499	399	66.13	49.97	1.13	O	0.53	N	52	0.8	6.0	78	92	170	10.84	5
BG0601-01	Chi Aok CF	1	K. Thom	Baray	Baray	Chi Aok	6010307	18	S	42.00	Y	N	Y	173	Community forest supported by MOE	173	138	62.43	91.68	16.30	O	1.17	N	18	0.3	2.1	27	32	59	10.82	6
BG0205-17	Kbal Taol	1	Battambang	Aek Phnum	Kaoh	Kbal Taol	2050705	54	N	59.7	Y	N	N	524		524	419	47.90	55.17	39.18	O	1.22	N	54	0.8	6.3	81	96	177	10.69	7
BG0301-02	Batheay	1	Kampong Cham	Batheay	Batheay	Batheay	3010102	77	N	56.1	Y	N	N	743		743	594	59.89	86.61	14.55	O	0.39	N	77	1.2	8.9	116	137	252	10.63	8
BG1710-31	Phum Prampir	1	Siem Reap	Siem Reab	Chong Khnies	Phum Prampir	17100707	37	N	11.9	Y	N	N	356		356	285	51.69	14.08	63.64	O	0.41	N	37	0.6	4.3	56	66	122	10.59	9
BG0407-01	Meanok FA Plantation	3	Kampong Chhnang	Sameakki Mean Chey	Tbaeng Khpos	Srae Mkak	4070806	66	S	52.00	Y	N	N	636	Meanok Governmental Forest Plantation 1500ha	636	509	30.95	79.54	0.00	O	2.47	N	66	1.0	7.6	99	116	215	10.59	10
BG1406-19	Ampov Prey	1	Prey Veng	Peam Chor	Kaoh Sampov	Ampov Prey	14060502	46	N	61.1	Y	N	N	438		438	350	64.84	57.77	22.94	O	1.22	N	46	0.7	5.3	69	81	150	10.56	11
BG0316-111	Trapeang Ruessei	1	Kampong Cham	Tboung Khmum	Roka Po Pram	Trapeang Ruessei	3161613	128	N	24.9	Y	N	N	1234		1234	987	67.75	97.62	12.42	P	0.38	N	128	2.0	14.8	192	227	419	10.44	12
BG1710-04	Trapeang Seh	1	Siem Reap	Siem Reab	Kouk Chak	Trapeang Seh	17100301	111	N	3.2	Y	N	N	1063		1063	850	83.73	87.89	5.11	O	0.22	N	111	1.7	12.8	167	196	363	10.43	13
BG0201-55	Ta Ngaen	1	Battambang	Banan	Ta Kream	Ta Ngaen	2010805	64	N	22.5	Y	N	N	612		612	490	47.71	77.71	0.65	O	0.81	N	64	1.0	7.4	96	114	210	10.41	14
BG0206-58	Prek Chik	1	Battambang	Moung Ruesse	Prek Chik	Prek Chik	2061005	101	N	53.4	Y	N	N	975		975	780	21.85	52.45	0.00	O	2.52	N	101	1.6	11.7	152	180	331	10.39	15
BG0507-154	Svay Dangkum	1	Kampong Speu	Samraong Ton	Skuh	Svay Dangkum	5071006	14	N	7.4	Y	N	N	139		139	111	15.11	91.28	0.00	P	0.00	N	14	0.2	1.7	21	26	47	1.88	6,289
BG0306-09	Preaek Yuon	1	Kampong Cham	Kampong Siem	Kien Chrey	Preaek Yuon	3060301	23	N	9.0	Y	N	N	217		217	174	11.52	96.92	1.15	P	0.00	N	23	0.3	2.6	35	39	74	1.83	6,290
BG0507-27	Kbal Tralach	1	Kampong Speu	Samraong Ton	Khtum Krang	Kbal Tralach	5070302	8	N	8.4	Y	N	N	80		80	64	15.00	89.97	0.00	P	0.01	N	8	0.1	1.0	12	15	27	1.83	6,291
BG0507-39	O Taroat	1	Kampong Speu	Samraong Ton	Khtum Krang	O Taroat	5070314	3	N	13.4	Y	N	N	32		32	26	12.50	94.19	-9999.00	P	0.01	N	3	0.1	0.4	5	7	11	1.77	6,292
BG2110-24	Prey Ph'av	1	Takeo	Treang	Roneam	Prey Ph'av	21100806	26	N	5.7	Y	N	N	247		247	198	10.12	92.83	0.00	P	0.00	N	26	0.4	3.0	39	46	85	1.74	6,293
									Total	200,329				1,006,033		1,006,033	804,844					2,922		104,644	1,620	12,098	156,966	185,571	342,537	37,130	
									Max	136				3,927		3,927	3,142	150.00	100.00			24.97		408.00	8.00	47	612	739	1,351	13.4	
									Mean	32				160		160	128	32.15	78.01			0.46		16.63	0.26	2	25	29	27	5.9	
									Min	2				5		5	4	10.00	0.43			0.00		1.00	0.00	0	2	1	0	1.7	

Source: JICA Study Team

Table 2.2.23 List of Solar BCS

Data to be Prepared by SP Team													Data to be Referred to Database and Calculated															
		Villages To be Electrified					Data for Priority Ranking						To be Quoted from Seila Database or 6 pro village survey						To be Quoted from GIS			Data to be Calculated						
							1	5	6	7	8				2-1	2-2	2-3	10	3		4			Cost ($1,000)				
ID No. of RE Scheme	Name of RE Scheme	Province	District	Commune Name	Village Name	ID No. by Seila	Maturity (A/R/S/N)	Renewabel Energy	Air distance to provincial capital or sub-center	Any coorprative activities (Y/N)?	Non electrified health post or schools etc.	Remarks	Village scale Nos of HH (hh)	Nos. of HH to be Electri-fied	Level of Grid RE by SEILA 2003 (%)	Dif-fusion level of TV by SEILA 2003 (%)	Diffusion level of RE by 6 pro vil. survey (%)	Level of Literacy	Hydro_Potential	Grassland per HH	Solar irradation in August	System Capacity (kWp)	Total Demand to SHS (Wp)	BCS	SHS	Total	Point for Priority Ranking Total	Rank
SP1604-12	Srae Ta Pan	Stung Treng	Sesan	Samkhuoy	Srae Ta Pan	19010403	N	S	9.22	N	Y	-Necessary to cross the Secon Ricer. (Map:6236)	95	76	0.00	0.00	8.42	12.36	0	0.00	4.50	4	0	25	0	25	13.85	1
SP1603-17	Kaoh Peak	Ratanak Kiri	Veun Sai	Kaoh Peak	Kaoh Peak	16090601	N	S	33.13	N	Y	-Beside Se san River (Map:6337) -Necessary to cross the Se san	178	142	0.00	0.00	4.49	0	0	0.10	4.24	6	0	37	0	37	12.39	2
SP1903-08	Koun Tnaot	Kampong Thom	Kampong Svay	Chey	Koun Tnaot	6020106	S	S	14.53	N	Y	-Access good (Map:5934) -Electrification rate high?	109	87	0.00	0.00	80.73	33.24	0	0.00	4.90	4	240	25	2	27	11.99	3
SP1103-03	Pu Hiem	Mondul Kiri	Ou Reang	Saen Monourom	Pu Hiem	11030201	N	S	13.82	N	Y	-Access good, Less than 1km foot path (Map:6433)	250	200	0.00	7.60	0.40	21.82	0	23.44	4.51	9	0	56	0	56	11.98	4
SP1905-41	Man	Stung Treng	Thala Bariva	Anlong Chrey	Man	19050502	N	S	30.44	N	Y	-Access very hard (Map:6136)	163	130	0.00	0.00	0.61	11.88	0	0.05	4.50	6	0	37	0	37	11.98	5
SP1903-17	Ta Ang Pok	Ratanak Kiri	Koun Mom	Ta Ang	Ta Ang Pok	16040302	N	S	9.48	N	Y	-Access good (Map:6336)	131	105	0.96	0.00	5.34	28.53	0	0.36	4.24	5	0	31	0	31	11.83	6
SP1609-02	La Meuy	Ratanak Kiri	Veun Sai	Kok Lak	La Meuy	16090703	N	S	29.97	N	Y	-Beside Se San River (Map:6336) -Access moderate. Necessary to	102	82	0.00	0.00	9.80	23.18	0	0.20	4.24	4	0	25	0	25	11.60	7
SP1101-02	Pohourn	Mondul Kiri	Kaev Seima	Chong Phlah	Pohourn	11010102	N	S	32.64	N	Y	-Access very hard. (Map:6334)	100	80	0.00	0.00	3.00	23.79	1	2.19	4.51	4	0	25	0	25	11.48	8
SP1903-26	Kok Lak	Ratanak Kiri	Veun Sai	Ka Choun	Kok Lak	16090406	N	S	30.50	N	Y	-Beside Se San River (Map:6336) -Access moderate. Necessary to	64	51	0.00	0.00	1.56	9.25	0	0.19	4.24	3	0	19	0	19	11.27	9
SP0602-03	Pokes	Mondul Kiri	Kaev Seima	Me Mang	Pokes	11010204	N	S	30.49	N	Y	-Access very hard. (Map:6334)	94	75	0.00	0.00	56.38	12.38	1	0.34	4.51	4	0	25	0	25	11.20	10
SP1606-20	Phak Nam	Ratanak Kiri	Veun Sai	Kaoh Peak	Phak Nam	16090602	N	S	30.56	N	Y		244	195	0.00	0.00	6.15	24.93	0	0.10	4.24	8	0	50	0	50	11.15	11
SP1105-01	Sek	Ratanak Kiri	Koun Mom	Ta Ang	Sek	16040304	N	S	11.73	N	Y		98	78	0.00	6.12	6.12	35.22	1	0.36	4.24	4	0	25	0	25	11.15	12
SP1305-02	Anlong Kramuon	Stung Treng	Thala Bariva	Srae Ruessei	Anlong Kramuon	19051002	N	S	15.88	N	Y		84	67	0.00	0.00	5.95	50.21	0	0.57	4.50	3	0	19	0	19	11.09	13
SP1604-14	Ta Ang Ka Tae	Ratanak Kiri	Koun Mom	Ta Ang	Ta Ang Ka Tae	16040301	N	S	8.71	N	Y		109	87	1.09	3.67	6.42	18.57	0	0.36	4.24	4	0	25	0	25	11.01	14
SP1606-04	Pu tru	Mondul Kiri	Ou Reang	Saen Monourom	Pu tru	11030203	N	S	9.36	N	Y		49	39	0.00	2.04	6.12	20.33	0	23.44	4.51	2	0	12	0	12	10.99	15
SP1305-31	Hang Savat	Stung Treng	Sesan	Samkhuoy	Hang Savat	19010404	N	S	9.12	N	Y		101	81	0.00	0.00	0.00	63.01	0	0.00	4.50	4	0	25	0	25	10.98	16
SP1903-12	Pa Dal	Ratanak Kiri	Ou Ya Dav	Sesant	Pa Dal	16070503	N	S	45.38	N	Y	Cherai ethnic group, use tree oils for light and have small hut as community hall	86	69	0.00	0.00	1.16	2.27	0	0.26	4.24	3	440	19	4	23	10.94	17
SP1102-14	Kang Kngaok	Stung Treng	Thala Bariva	Kang Cham	Kang Kngaok	19050304	N	S	20.82	N	Y		107	86	0.67	0.00	1.87	19.13	0	0.00	4.50	4	0	25	0	25	10.94	18
SP0905-01	Pu Antraeng	Mondul Kiri	Ou Reang	Dak Dam	Pu Antraeng	11030101	S	S	14.51	N	Y		117	94	0.00	5.13	0.00	39.83	0	43.79	4.51	4	240	25	2	27	10.83	19
SP1101-10	Anlong Svay	Stung Treng	Thala Bariva	Ou Rai	Anlong Svay	19050603	N	S	5.03	N	Y		122	98	0.00	1.64	0.82	55.86	0	0.55	4.50	4	0	25	0	25	10.81	20
SP0602-19	Ker	Preah Vihear	Rovieng	Rotanak	Ker	13050701	S	S	10.33	N	Y		215	172	0.00	0.00	62.79	48.34	0	0.00	4.59	7	0	43	0	43	10.79	21
SP1103-02	La En	Ratanak Kiri	Koun Mom	Toen	La En	16040402	N	S	17.84	N	Y	There is around 20W PV, one 11W lamp and 50 Ah battery at school but not enough for study. Small hut as cummunity	110	88	0.00	6.36	5.45	32.35	0	3.10	4.24	4	680	25	7	32	10.77	22
SP1607-25	Rak	Ratanak Kiri	Veun Sai	Kok Lak	Rak	16090702	N	S	33.96	N	Y		115	92	0.68	0.00	6.09	5.51	0	1.45	4.24	4	0	25	0	25	10.77	23
SP1606-02	Pa or	Ratanak Kiri	Ou Chum	Aekakpheap	Pa or	16060301	N	S	11.34	N	N		107	86	0.00	4.67	2.80	10.04	0	0.21	4.24	4	0	25	0	25	10.76	24
SP1905-21	Ta Heuy	Ratanak Kiri	Koun Mom	Toen	Ta Heuy	16040403	N	S	14.16	N	Y	There is around 20W PV, one 11W lamp and 50 Ah battery at school but not enough for study. Small hut as cummunity	123	98	0.00	2.44	5.69	39.13	0	3.10	4.24	4	680	25	7	32	10.73	25
SP0506-07	Khlong Tboung	Kampong Cham	Memot	Chan Mul	Khlong Tboung	3100111	N	S	87.51	N	N		40	32	2.23	2.50	-9999.00	72.36	0	0.00	4.90	2	0	12	0	12	-0.71	1715
SP0508-01	Kbal Damrei	Kampong Thom	Sandan	Tum Ring	Kbal Damrei	6060905	N	S	59.18	N	N		50	40	-9999.00	4.00	74.00	85.04	0	0.09	4.90	2	0	12	0	12	-0.96	1716
SP2202-07	Tonloab	Banteay Meanch	Preah Netr P	Tuek Chour	Tonloab	1040805	N	S	41.37	N	N		35	28	-9999.00	8.57	-9999.00	75.21	0	0.04	4.55	2	0	12	0	12	-1.21	1717
SP0408-01	Chub Korki Khanglich	Otdar Meanchey	Banteay Ampi	Ampil	Chub Korki Khanglich	22020115	N	S	39.61	N	N		34	27	0.76	5.88	-9999.00	91.89	0	0.05	4.90	2	0	12	0	12	-1.43	1718
SP2104-17	Panhchak Lea	Kampong Thom	Prasat Sambo	Koul	Panhchak Lea	6050207	N	S	44.02	N	N		52	42	1.06	9.62	28.85	91.77	0	0.01	4.90	2	0	12	0	12	-1.51	1719
SP0104-07	Sam	Ratanak Kiri	Ou Ya Dav	Ya Tung	Sam	16070705	N	S	56.52	N	N		51	41	-9999.00	1.96	-9999.00	94.35	0	1.04	4.24	2	0	12	0	12	-1.64	1720
							Total		69,328				237,489	190,000					70	1,609	7,849	8,487	24,760	52,678	213	52,891	7,970	
							Max		116				726	581						43.79	5.09	24	680	149	7	149	13.85	
							Min		1				6	5						0.00	3.44	1	0	6	0	6	-1.64	
							Mean		40				138	111						0.94	4.56	5	14	31	0	31	4.63	

Source: JICA Study Team

Volume 2 Master Plan

Part 1	**Baseline Study**
Part 2	**Master Plan**
Part 3	**Rural Electrification Plans**

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

FINAL REPORT
VOLUME 2 : MASTER PLAN

Table of Contents

List of Tables

List of Figures

Part 3 Rural Electrification Plans

1. RURAL ELECTRIFICATION PLANS BY RENEWABLE ENERGY

1.1 MICRO HYDRO MINI GRID

1.1.1 Planning of Mini-Grid with Micro Hydro

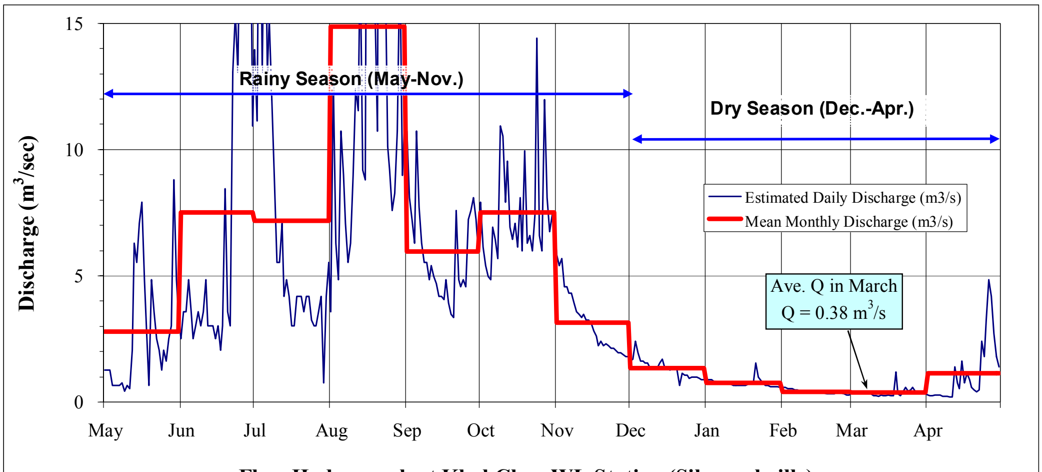
Basic policies in formulating electrification plans by micro hydro are as follows.

1) Micro hydro mini grid is planned to supply electricity to villages in the off-grid area.

2) Micro hydro should supply electricity to the target village(s) even in the dry season

To take into account of above policies, one of the most important factors is to assess dry season output of micro hydro to enable power supply even in the dry season.

In Cambodia in general, dry season discharge of the river draws down significantly compared with the wet season discharge as shown in Figure 1.1.1. Therefore if micro hydro is planned using wet season discharge, people in the target villages may face power shortage in the dry season. To avoid such power shortage situation, micro hydro min grid need to be planned based on dry season discharge.



Flow Hydrograph at Kbal Chay WL Station (Sihanoukville)
(May 2001 - April 2002)

Source : Observed Daily Gauge Height Record: Department of Water Resources and Meteorology, Sihanoukville
Daily Discharge : Esimated by JICA Study Team

Figure 1.1.1 Sample Hydrograph of Small River in Cambodia

One possible solution for dry season power shortage is to compensate power shortage using back-up diesel. However, micro hydro scheme is, in most cases, located in the mountainous area where diesel oil cost is higher due to difficulties in transportation. Further, back-up diesel will need additional initial cost. Therefore it is preferable to supply electricity only by micro hydro from economical point of view.

Back-up power supply from national grid is not considered because the target villages are located in the off-grid area which is normally far from national grid.

Another solution is to apply hybrid system with biomass gasification power generation. But hybrid system is normally considered for rather large scale demand in an order of more than 100 kW or thereabout. In a mountainous small village, application of hybrid system will rather be limited.

Considering above situations, micro hydro mini grid scheme is formulated using dry season output based on dry season river discharge.

1.1.2 Constraints on Development of Micro Hydro

(1) Significant Draw Down of Dry Season Discharge

Through field surveys conducted from December 2004 to February 2005 and May, June 2005; the Study Team realized that there is a significant draw down of dry season discharge compared with that of wet season. Such characteristics are assessed in detail in Chapter 5 of Part 1.

(2) Gentle Slopes of Rivers

Through map study and leveling survey works at site, the Study Team realized that it was very difficult to find high head in a short distance. In Cambodia, riverbed slopes are generally very gentle except for locations with waterfall. Such geographical characteristics make micro hydro power less attractive and make development cost higher.

(3) Identification of Potential Sites for Micro Hydro

For development of micro hydro scheme, information on existence of perennial waterfalls or fountains is sometimes quite useful for formulation of village electrification schemes. Such information is normally supplied by village people. However, due to significant draw down of river discharge in the dry season as mentioned above, such information was hardly available.

In order to identify potential sites for micro hydro, desk study was made using maps with 1:100,000 and 1:50,000 scales. Detailed explanation is given in Chapter 5 of Part 1.

Through map study, 145 numbers of micro hydro schemes were identified as listed in Table 1.4.1 of Chapter 1 of Part 2.

1.1.3 Identification of Target Villages

Locations of identified micro hydro potential sites are as plotted in Figure 5.1.8 of Chapter 5 of Part 1. As shown in Figure 5.1.8, most of micro hydro potential sites are located in

1) the mountainous region in the south western part (hereinafter called as "South Western Part") covering southern part of Battambang, Pursat, Koh Kong, Kampong Speu and Kampot, and,
2) the mountainous region in the north eastern part (hereinafter called as "North Eastern Part") covering Stung Treng, Ratanak Kiri, Mondul Kiri and Kratie.

Characteristics of villages in the potential area can be popped up by checking the following three indicators of (1) Village Size, (2) Illiteracy Rate and (3) Diffusion of TV.

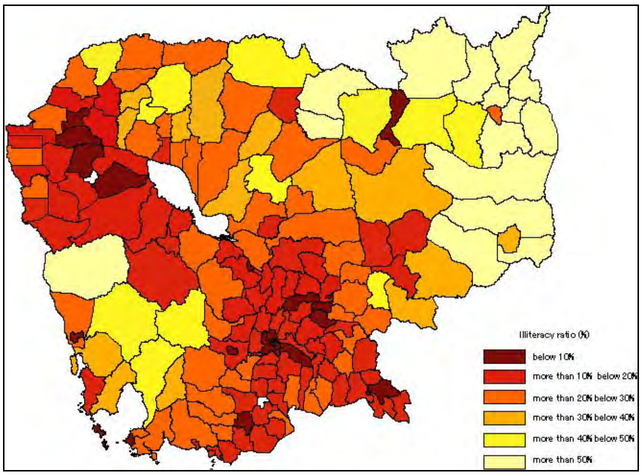
(1) Village Size

Village distribution and their size, average village size by province are classified in Figure 4.2.1 of Part 1. By comparing Figure 4.2.1 (village size) and Figure 5.1.8 (micro hydro potential site), it can be said that micro hydro potential sites/area of "South Western Part" and "North Eastern Part" are located in the village sparse area. Further the size of village is smaller in those areas, with an order of less than 100 household.

During the course of assessment of demand-supply balance, it was realized that out of 145 micro hydro potential sites identified through map study, only 44 potential sites have villages to supply electricity. Other 101 schemes have no villages to supply nearby or too sparsely populated area for micro hydro installation.

(2) Illiteracy Level

Figure 1.1.2 shows illiteracy level by district. By comparing above map with micro hydro potential map (Figure 5.1.8 of Part 1), micro hydro potential area especially "North Eastern Part" is located in areas with high illiteracy ratio. By installation of micro hydro in such area, it may contribute to level up of literacy ratio through learning to read during night time. On the other hand, high illiteracy ratio means that people in those areas might live with very low income, of which people can not afford to pay for electricity.

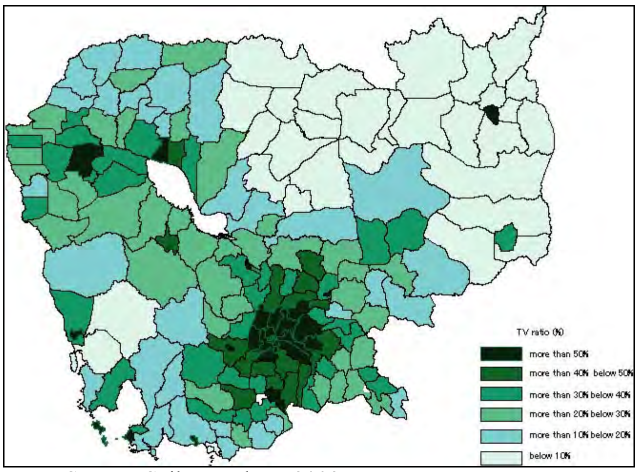


Source: Seila Database 2003

Figure 1.1.2 Illiteracy Level by District

(3) Diffusion of TV

Figure 1.1.3 shows diffusion level of TV by district. TV users are considered to have potential electricity demand with an order of 50 to 100 watt per household. However, in micro hydro potential area, especially "North Eastern Part", TV diffusion level is less than 10%. Even in "South Western Part", TV diffusion level is between 20% to 10% or less. This means that even there is certain micro hydro potential to develop with sufficient village size, it is necessary to assess village demand and its maturity to apply mini grid by micro hydro.



Source: Seila Database 2003

Figure 1.1.3 TV Diffusion Level

If village demand and people's affordability to pay is not so high as to apply mini grid, such villages should be classified into "Battery Lighting" group.

1.1.4 Formulation of Village Electrification Scheme

By using the GIS Village Map together with 1:100,000 and 1:50,000 topographic maps, formulation of village electrification scheme was made through assessment of micro hydro potential and village demand. Detailed procedures are explained below. Flow chart for the following procedures is as shown in Figure 1.1.4.

(A) Check the total head (*H*) by checking counter lines on the map.

(B) Layout locations for intake and power house on the map.

(C) Check the catchment area at the intake.

(D) Estimate dry season output with the following equation.

$$P = 9.8 \text{ x } Q \text{ (m}^3\text{/sec) x } H \text{ (m) x } \eta$$

Where;

$Q = CA$ (km^2) x assumed dry season specific discharge (m^3/sec/km^2)

i) For assumed dry season specific discharge, refer to Figure 5.1.7 of Chapter 5 of Part 1.

ii) In case actual measured dry season discharge is available, use that value as Q.

H: total head checked in (A) above

η : efficiency, (assumed as 0.7)

(E) Prepare layout of micro hydro scheme to estimate cost for structures. Detailed cost estimate method is given in Section 5.5 of Volume 3 Part 2.

(F) From micro hydro potential site, find the nearest village to supply electricity. If no village found within 15 to 20 km distance, the potential site is judged to have no village to electrify.

(G) Check the distance from potential site to the village along existing road. This distance will be later used as length of medium voltage transmission line (MV line).

(H) If the MV line length is adequate, check the total village demand against potential.

(I) If the potential is still sufficient for further demand, check the MV line length to the next nearest village.

(J) Check the total MV line length counted so far.

(K) If the total MV line length is still adequate, check the demand in the village.

(L) Check the total demand in the villages counted so far.

(M) If the potential is still sufficient for further demand, check the MV line length to the next nearest village.

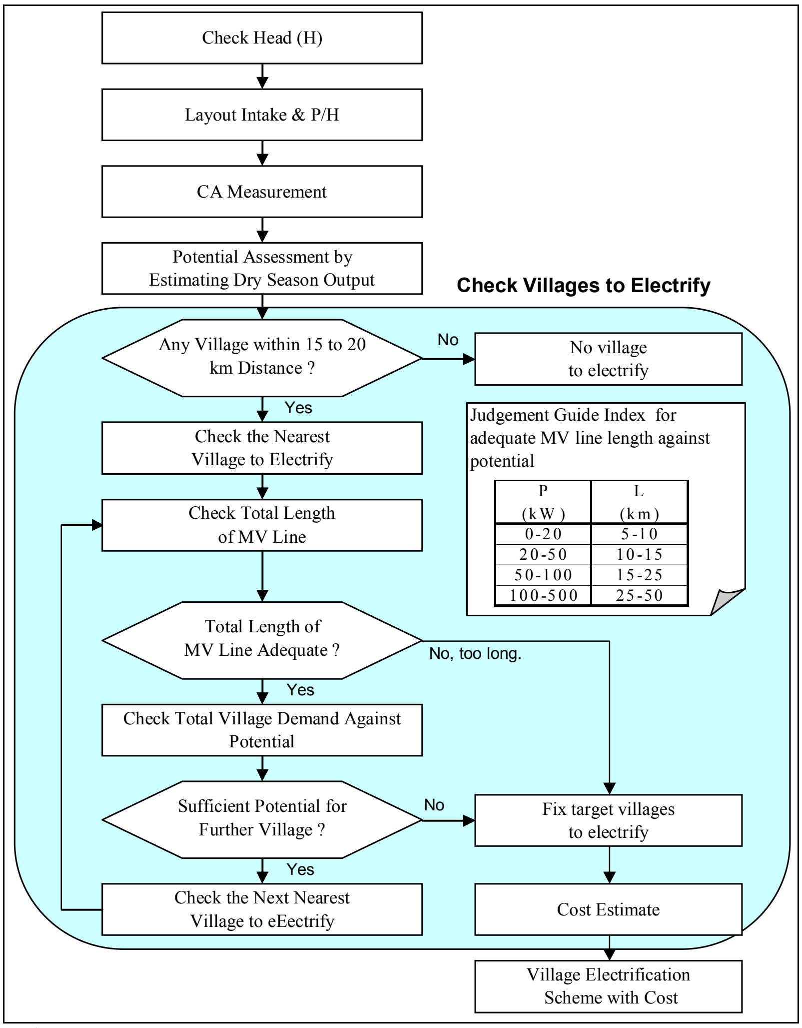
(N) Repeat procedures from above (J) to (M).

(O) If the total demand exceeds potential or total length of MV line becomes too long, stop checking the demand of the next nearest village. And make the total demand so far counted within the potential. These villages are fixed as target villages for electricity supply.

(P) Estimate construction cost (Refer to Section 5.5 of Volume 3 Part 2).

Out of 145 schemes (listed in Table 5.1.4 of Part 1) identified through map study, it was realized that 44 schemes had villages for electricity supply. For the rest of 101 schemes, there is no village to electrify near the micro hydro potential site. For such potential site, distance to the nearest village is

20 km or farther. These 44 schemes are shown in the Table 1.1.2.



Source: JICA Study Team

Figure 1.1.4 Flow Chart for Formulating Village Electrification Scheme by MHP

1.1.5 Field Survey on Selected Micro Hydro Sites

To check of the potential for micro hydro power of selected/screened scheme, following field surveys were conducted at the proposed sites.

1) Installation of water level staff gauge (at selected sites)
2) Discharge measurement by using a current meter
3) Leveling survey to measurement of head (height difference from proposed intake site to power house site) by using a hand level or Auto-Level

Reconnaissance of the prospective micro hydro sites was conducted during the 1st to 3rd field survey period (December 2004 - June 2005) jointly by the JICA Study Team and MIME staff. A total of more than 30 sites were inspected. Summary of field survey on the selected candidate sites for micro hydro power scheme are shown in Table 1.1.3.

Table 1.1.1 Survey Results of Potential MHP Sites

Name of MHP Scheme	Province	District	River Name	Q Obs. Site (UTM: Indian-Thai) GPS X (E)	GPS Y (N)	C.A. (km^2)	WL Staff Gauge Installed	100% Observed Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)	Date	Gross Head (m)	(η = 0.7) Potential Power Gen. (kW)	No. of Househol (HH)	Remarks
Stung Sva Slab	Kampong Speu	Phnum Snoch	Sva Slab	*03 95 710*	*12 61 360*	205 [2)]	2005/4/21 Installed by MIME	**0.096** [1)]	0.0005	2004/12/4	***85.0*** [2)]	**56**	665 [5)]	Meritec Study (2001) [3.80MW] *2)
O Kachan	Ratanak Kiri	Lumphat	O Kachan	07 15 659	15 14 518	31.2 [4)]	-	**0.350** [1)]	0.0112	2005/1/19	**13.2** [1)]	**32**	98 [5)]	MIME List [82kW] *2)
O Katieng	Ratanak Kiri	Lumphat	O Katieng	07 14 128	15 11 427	42.9 [4)]	-	**0.410** [1)]	0.0096	2005/1/19	**14.1** [1)]	**40**	295 [5)]	Meritec Study (2001) [1076kW] *2), MIME List [224kW]
Bay Srok (O Sien Ler)	Ratanak Kiri	Lumphat	O Sien Ler (O Paling Thom)	07 26 215	15 03 449	115.0 [3)]	2005/1/20 Installed by JST	**1.070** [1)]	0.0093	2005/1/20	**23.2** [1)]	**170**	560 [1)]	Meritec Study (2003) [78kW] *3)
								0.410 [1)]		2005/5/20	**23.3** [8)]	**65**	560 [1)]	
O Chrolong	Stung Treng	Sienbok	O Chrolong	06 19 514	14 76 863	128.0 [1)]	2005/1/24 Installed by JST	**0.450** [1)]	0.0035	2005/1/23	**4.8** [1)]	**15**	103 [5)]	Proposed by DIME, Survey by JST (2005)
								0.320 [1)]		2005/5/22	**4.8** [1)]	**10.4**	103 [5)]	
Busra	Mondul Kiri	Pechr Chenda	Prek Por	*07 64 312*	*13 90 088*	197.0 [1)]	2005/5/20 Installed by JST	**0.150** [1)]	0.0008	2005/1/27	***65.0*** [1)]	**67**	899 [5)]	Meritec (2003) [54kW] *3), 23m & 42m for 1st & 2nd fall. Supply to Busra Commune
								2.050 [1)]		2005/5/20	***68.2*** [8)*]	**959**	899 [5)]	8)* Partly hand level applied
O Phlai	Mondul Kiri	Pechr Chenda	O Phlai	*07 58 800*	*13 87 700*	302.0 [1)]	2005/5/21 Installed by JST	**0.330** [1)]	0.0011	2005/1/27	***40.0*** [7)]	**91**	899 [5)]	Supply to Busra Commune
								0.470 [1)]		2005/5/21	***23.5*** [8)**]	**76**	899 [5)]	8)** Head will be developed more. Levelling was interrupted by time limitation.
Sangke (D/S)	Battambang	Samlot	Stung Sangke	*02 68 875*	*14 11 162*	696.0 [1)]	2005/4/7 Installed by MIME	**1.150** [1)]	0.0017	2005/2/5	***15.0*** [6)]	**118**	6786 [5)]	Mine clearing is required for further survey
								2.830 [1)]		2005/5/14	***7.5*** [8)]	**145**	6786 [5)]	
								2.880 [1)]		2005/5/15	***7.5*** [8)]	**147**	6786 [5)]	
Sangke (U/S)	Battambang	Samlot	Stung Sangke	*02 55 200*	*14 02 400*	499.0 [1)]	-	***0.824*** [6)]	0.0017	2005/2/5	***15.0*** [6)]	**85**	6786 [5)]	
Tatai (D/S)	Koh Kong	Thmabang	Stung Tatai	03 25 927	12 89 335	423.0 [1)]	Auto.WL. gauge was installed by ADB/ MIME, 2004	**0.284** [1)]	0.0007	2005/2/11	**32.0** [1)]	**62**	155 [5)]	Auto W.L. gauge was installed by ADB (2004).
								No measu -rement	-	2005/6/1	**30.2** [8)]	**62**	155 [5)]	
								0.031 [1)]		2005/2/12	**28.0** [1)]	**6**	92 [1)]	
Ou Sla (D/S) (Chhay Areng D/S)	Koh Kong	Sre Amble	Ou Sla	*03 76 880*	*12 38 770*	86.0 [1)]	2005/4/22 Installed by MIME	***0.344*** [7)]	0.0040		***120.0*** [6)]	**283**	1249 [1)]	To be surveyed in next May

Source: *1): JICA Study Team (JST) Surveyed
*2): "Pipeline Development Program of Small Hydropower Project in Cambodia", WB / Meritec, (2001).
*3): "Pre-Investment Study of Community-Scale Hydro Projects, Cambodia", NZ MoFA&T, Meritec (2003).
*4): MIME
*5): SEILA GIS Data Base
*6): Eye measurement/Estimated figures
*7): Assumed.
*8): Measured by Auto Level

Source: JICA Study Team

1.2 BIOMASS MINI GRID

1.2.1 Appropriate Biomass Electrification Technology

(1) Direct Combustion and Gasification

There are two major biomass electricity generation systems using solid biomass, direct combustion and gasification. Direct combustion is the most common way of converting biomass to energy. For generating electricity, a biomass-fired boiler transfers the heat of combustion into steam. Steam drives turbine-generator to produce electricity. This system is a proven technology and introduced to many agricultural products processing factory around the world. The system is suitable for rather large scale (e.g. > 1 MW) and probably not appropriate for rural electrification in Cambodia, in the off-grid area in particular since its scale there would be only 10-500 kW class.

Gasification is a thermochemical process that converts biomass into a combustible gas called producer gas which contains about 80% of the energy originally present in the biomass. The producer gas is sent through a cooling and purifying unit before feeding into the engine to generate electricity (Figure AP-C.1.1.). This is relatively new technology but number of application for practical use is increasing rapidly. The system is available as small as 4 kW to mega watt scale. We conclude this is the most appropriate system to be used for rural electrification in Cambodia.

(2) Bio-digestion Gas

The technology is available for electricity generation using bio-digestion gas derived mainly from excreta of domestic animals. But small scale systems are not commercialized yet. For generating stable electricity for typical village size (140 households) requires a cattle shed of more than 30 cows, which is rarely seen in rural villages. The low cost (< $50 for a family size unit) plastic digester system which provides gas to be used for cooking has been introduced to many villages by NGOs. Under the current situation, bio-digestion gas seems more appropriate to be used for cooking than generating electricity at rural villages.

(3) Bio-diesel

A conceivable option to accelerate rural electrification is through the use of diesel-equivalent oil (bio-diesel) made through transesterification[1] of cooking oil derived from biomass, as an alternative fuel for diesel power generation. The use of bio-diesel has already begun in Europe and the United States, where it is blended with diesel oil to fuel automobiles.

However, the following issues need to be addressed when considering bio-diesel as a source of energy for off-grid rural electrification.

i) there is risk for oil crops, apart from Jatropha, to conflict with existing agricultural production.

ii) the cost is still higher than conventional diesel oil.

iii) as it is made from canola, palm, sunflower and soy, there is possibility of conflict with their use as foodstuff or cooking oil.[2]

iv) insufficient record on use for power generation.

v) reactors of certain scales, as well as logistics networks corresponding to the processed volume generally need to be established.[3]

The use of bio-diesel should be discussed comprehensively as a national energy issue, rather than limiting to the context of rural electrification, and therefore was omitted as a potential source of energy for rural electrification.

Much attention is being paid to the production and use of bio-fuel, including bio-ethanol and bio-diesel, even in the developing countries, due to the surging oil prices as was seen at the end of the 6th Field Study in February 2006. The use of bio-diesel for blending with diesel oil is becoming common, and its use for rural electrification may open up if the following issues can be overcome.

i) existing agricultural activities are not obstructed by the production of oil crops.

ii) fuel cost becomes cheap enough in comparison to diesel oil, and is within the affordability to pay of the villagers.

1 The chemical reaction to synthesize with methanol, thereby reducing molecular weight and making its property closer to that of diesel oil. Jatropha originally has small molecular weight, and therefore is said to become a diesel-equivalent oil simply by expelling the oil.

2 Jatropha is a shrub and is resistant to dry weather. As its plantation in RGC is possible in unutilized grasslands and shrublands, the risk of conflict with farming of agricultural crops is low.

3 Decentralized small-scale plants are technically possible, because the reaction only consists of mixing biomass derived oil with methanol and sodium hydroxide.

iii) power generation by bio-diesel alone (100%) becomes possible through modification of gensets, etc.

iv) cheap small-scale oil expeller/reactor becomes commercially available.

An European NGO has installed a small-scale reactor in RGC in mid-2005 to disseminate the technology. It is reported that, although it may not be applicable to run an automobile, it can be used for fixed gensets. It is worthwhile to be on the lookout for developments in this technology.

1.2.2 Biomass Mini Grid

The mean number of households of our target group is 140. Expected monthly power usage per household is 10 kWh. The annual electricity generation would be 16,800 kWh. Appropriate system to generate this amount of electricity is discussed below:

(1) Biomass Fuel Supply

We consider that tree farming is the most appropriate method for biomass fuel supply because of several reasons described in Part 2 Chapter 1.4.4. The woody biomass fuel efficiency for generating electricity is roughly about 1.5 kg/kWh therefore 25 dry ton of wood is required annually. We define the annual woody biomass productivity as 10 t/ha although the productivity of fast growing legume species would be higher at most area of Cambodia. Land required for planting trees for sustainable fuel wood supply is total about 2.5 ha. In other words, 0.018 ha land per household is required for tree planting. All villages selected for biomass electrification scheme in this Master Plan has more than 0.02 ha per household grassland and shrubland presumed to be suitable for tree planting. Even the villages where grassland and shrubland exist less than 0.02 ha per household might have sufficient land for tree planting because the required land area for tree farming can consist of many small blocks and trees can be planted road side, garden edge or association with food crops as agroforestry. Fast growing nitrogen fixing multipurpose tree species such as *Cassia* spp. *Leucaena* spp. and *Gliricidia* spp are appropriate for tree farming because they have generally positive impact to soils and their foliages, flowers, fruits and seeds can be nutritious food source for both human and domestic animals.

Where excess biomass residues such as rice husk are available, they should be fully utilized for electricity generation. About 2 kg rice husk is needed for 1 kWh electricity generation. About 240 kg of rice husk is required for each household and about 34 t of rice husk is required to generate electricity for 140 households village for a year. Such amount of rice husk can be supplied by one small scale commercial rice mill (much bigger than village rice mill). Even if sufficient excess residues are expected to be available, a certain area (0.05 ha/kW) of tree farm should be established as back up fuel source.

(2) Appropriate Systems

The depreciation of equipments is a major part of unit electrification cost (38%, see Part 1, Section 3.7.3). It is critical to operate full capacity of the system to reduce the unit cost. The daytime usage is an important key of success of rural biomass electrification. The existence of rice miller or other major daytime users is preferable for installation.

Electrification plan with biomass gasification power has been formulated for 6,328 villages. Of these 13 schemes manually formulated based on field survey and hearing from NGO covered 48 villages. The top ranked 10 schemes are listed in Table 1.2.1.

Table 1.2.1 Top Ranked 10 Mini-Grids with Biomass Gasification Power

No.	Province	Name of Scheme	Source of Energy	Fuel Sources	Assumed Nos. of hh to Electrify	Installed Capacity (kW)
1	Pursat	Phnum Kravanh Bio	Biomass	Planted fuel wood	3142	408
2	Kampong Chhnang	Svay Bakav CF	Biomass	Wastes from community forest	274	36
3	Kampong Thom	Kraya CF JICA	Biomass	Planted fuel wood	858	112
4	Takeo	Takeo CelAgrid	Biomass	Planted fuel wood	963	125
5	Kampong Cham	Krasang	Biomass	Planted fuel wood	399	52
6	Kampong Thom	Chi Aok CF	Biomass	Wastes from community forest	138	18
7	Battambang	Kbal Taol	Biomass	Planted fuel wood	419	54
8	Kampong Cham	Batheay	Biomass	Planted fuel wood	594	77
9	Siem Reap	Phum Prampir	Biomass	Planted fuel wood	285	37
10	Kampong Chhnang	Meanok FA Plantation	Biomass	Planted fuel wood	509	66

Source: JICA Study Team

1.3 BATTERY LIGHTING WITH SOLAR BCS

In some cases due to the burden or bitter experiences especially replacement of battery officers of many aiding agencies are reluctant to take up a grant scheme of SHS. Ownership of SHS that is installed within individual home inevitably belongs to individual. Solar powered mini-grid is limited in its supply capacity while users tend to consume as much power as they need as if they are receiving power supply from large power distribution systems.

Therefore, in the Master Plan, solar BCS is recommended instead of SHS or solar mini-grid to provide battery lighting in remote villages. In addition public PV system is also recommended to provide battery lighting for night-school, commune hall, and/or health post/center. At public PV system where villagers can afford to buy batteries for home use, BCS function may be added as an option.

To implement many solar BCS or PV system countrywide, it is required to establish a standard deign of such system. As the system will be scattered around the whole country, solar schemes is first formulated for each village and then may be packaged by district or province to have a project scale suitable for implementation with a grant.

(1) Grouping households

In remote areas households are scattered and walking distance up to BCS for battery charging becomes long if large system is installed at one place. It is preferable to plan BCS for each non-electrified village instead of installing one large system in one commune. The capital cost depends on the number of battery users. Splitting of one commune BCS to many village BCS will not significantly affect the costs. In view of the median size 140 households in Cambodia and smaller size of non-BCS villages in general, hence the village sizes are categorized into four groups:

BCS Model 25: from 1 to 25 households

BCS Model 50: from 26 to 50 households

BCS Model 75: from 51 to 75 households

BCS Model 100: from 76 to 100 households

For the large village with more than 100 households, combination of standard Models above is adopted.

(2) System deign parameters

To decide the capacity of each above BCS Model, it is required to estimate the daily power demand of individual household, capacity of batteries to be charged, and solar potential of the site.

Power Demand & Type of Batteries: From the site survey it is understood that in an average 50 Ah batteries are used mostly for lighting, 70 Ah for lighting and B/W TV, and 100 Ah for lighting and color TV or for lighting and Karaoke deck with color TV screen. Normally the charging intervals are 10 days. The light and color TV holders charge their batteries more frequently depending upon the consumption or hold another battery for TV. Numbers of TV holders or Karaoke business are few in general. The battery share by capacity is estimated as shown below:

(i) 50 Ah battery 30% of number of households using BCS

(ii) 70 Ah battery 50%

(ii) 100 Ah battery 20%

Charging Interval: Although current practice of battery charging is mostly in every 10 days after full use of the battery capacity, it is recommended in the Master Plan that the battery be charged in every 5 days:

1) to avoid deep discharging of battery, which will deteriorate battery; and
2) to provide time allowance for battery charging in case BCS cannot fully charge customers batteries in rainy days (in such days customers may need to wait for a few days until completion of the battery charging).

Solar Irradiation : To determine the capacity of PV module it is essential to know the solar irradiation of the site. Solar irradiation is estimated based on the satellite data of NASA. The annual average of the country is 5.1kWh/m^2/day and the minimum average is 4.6kWh/m^2/day. Solar irradiation goes down in the rainy season for the months from June to September. To generate power at the maximum level, PV panel is to be faced toward sun (south in northern hemisphere) at an angle of the site latitude as practiced around the world. With this inclined panel, total power generation will be maximized. Setting of PV panels at inappropriate inclined angle will decrease the power output of the system. The optimum angle varies with months depending on the position of sun. Hence, Cambodia is divided into two groups for system deigning. Table 1.3.1 represents the Provinces under the group on the base of solar irradiation and incline angle of PV to generate maximum power on lower irradiation months.

Table 1.3.1 Grouping of Provinces by Solar Irradiation

Group	Province	Irradiation ($kWh/m^2/day$)	Inclined angle of PV (in Degree)
1	Kampot, Koh Kong, Pursat and Takeo	4.6	5
2	Other provinces	5.1	10

Source: JICA Study Team

System deign parameters: In addition to the above, there are some other factors to be taken into consideration in the system design of solar BCS. In case of PV system for social electrification system as it is connected to the storage battery some of the system deign parameters are different from BCS. Table 1.3.2 presents the design parameters for both solar BCS and PV SYSTEM for social electrification.

Table 1.3.2 Design Parameters of Solar BCS and PV System for Social Electrification

Item	Parameter	Value for		Unit	Remark
		BCS	PV		
1	Horizontal solar irradiation	5.1	5.1	$kWh/m^2/d$	Country average (satellite data)
2	Module derating factor	10	10	%	Decrease of output due to dirt, years of uses and so on.
3	Columbic efficiency	90	90	%	To charge battery effectively.
4	Charge controller (C/C) consumption	10	*	mA/day	Depends on manufacturer
5	Depth of discharge (DOD) of battery	50	80	%	50% for shallow cycle lead acid and 80% for deep cycle
6	Charging interval	5		days	To avoid deep discharge
7	Days of autonomy		3	days	Reservation for NO SUN days
8	Voltage output from charge controller (C/C)	13.5	13.5	V	Minimum voltage to charge battery effectively
9	C/C capacity	10	*	Amp	To charge battery effectively
10	Battery to be charged	50, 70 & 100	*	Ah	Present battery size charged at DG BCS

Source: JICA Study Team
Note: (1) Blanks means non required parameters. (2) '*' means load demand is required to estimate the value.

Depending upon load size of public facilities the capacity of the system will vary. Here it is assumed that the facilities such as health post, night school and community hall are the place where *social electrification* by PV system will be established. Table 1.3.3 summarizes the required capacity of PV, battery, charge controller and hours of uses in a day.

Table 1.3.3 Standard PV System for Public Facilities

Model No.	Type of Public Facilities	Nos. of Fluorescent Lights and hours of use						Capacity of battery (12V DC)	Size of C/C	PV Capacity
		20W	h/day	Total (W)	40W	h/day	Total (W)	Ah (@10hr)	Ah (12V)	Wp
1	Health post	4	3	160	4	3	480	240	20	350
2	Night School	4	3	160	10	3	1,200	471	40	700
3	Community Hall	2	2	80	4	2	320	138	12	200

Source: JICA Study Team

(3) Capacity and Cost of each system

With the design parameters above, the standard solar BCS and PV system for social electrification is deigned. Below Tables 1.3.4 and 1.3.5 present the capacity and system cost of standard solar BCS Models & PV system for social electrification respectively.

From the details system sizing it found out that in the case of solar BSC if required capacity is rounded up to a digit than calculated system capacity on the base of country annual and minimum average solar irradiation becomes same. The detail system sizing and cost calculation of solar BSC are given in **Appendix-B**.

Table 1.3.4 Capacity of Standard BCS Model and Costs

Group	Percentage (%) of batt. to be charged by the system			No. of batteries charged per day	System Capacity (kWp)		System Cost US$ (before taxes)	
	50 Ah	70 Ah	100 Ah		At 4.6 (kWh/m^2/d)	At 5.1 (kWh/m^2/d)	for 4.6 (kWh/m^2/d)	for 5.1 (kWh/m^2/d)
BCS Model 25	30	50	20	5	1	1	6,279	6,279
BCS Model 50				10	2	2	12,458	12,458
BCS Model 75				15	3	3	18,636	18,636
BCS Model 100				20	4	4	24,815	24,815

Source: JICA Study Team

Table 1.3.5 Capacity of PV System for Public Facilities and Costs

Model No.	Type of public facilities	PV capacity (Wp)	Total system cost US$ (before Taxes)
1	Health post	350	2,333
2	Night school	700	4,638
3	Community hall	200	1,426

Source: JICA Study Team

Furthermore to derive the system capacity, the following conditions are assumed:

Power of single module is assumed 50Wp.

Current output of single PV module is assumed 3.0 Amp.

Required capacity is rounded up to a digit (this provides some allowance in the capacity).

PV system voltage is selected to charge battery even at a high ambient temperature (35^o Celsius).

Battery needs to charge completely in a day by for solar BCS at deigned solar irradiation level.

(4) Candidate villages for solar schemes and total cost

Of the 11,752 villages situated in the off-grid area, 1,759 villages are selected as candidates for solar

BCS schemes. These villages are mostly located in the north and northeast part of the country where households are scattered comparing to the central and southern parts of the country.

Total number of candidate village:	1,720
Average household number at village:	138
Total number of households to be covered:	237,570

From the above an average cost per individual household is about US$250. With this unit cost, the total cost is estimated to be about US$60 million.

(5) Selection of the system type

Among the candidate villages for solar schemes, if there are non-electrified public facilities like health post, night school or commune hall then *Social Electrification* with public PV system will be applied. If not, *Remote Electrification* with solar BCS will be applied.

2. ASSESSMENT OF ELECTRIFICATION PLANS AND RECOMMENDATIONS

2.1 ENVIRONMENTAL IMPACT ASSESSMENT AND RECOMMENDED GUIDELINES

2.1.1 Environmental Impact Assessment

(1) Environmental Regulations in Cambodia

Article 59 of the Constitution of the Kingdom of Cambodia stipulates that "The State shall protect the environment and balance of abundant natural resources and establish a precise plan of management of land, water, air, wind geology, ecological system, mines, energy, petrol, and gas, rocks and sand, gems, forests and forestrial products, wildlife, fish and aquatic resources."

Based on the Article 59 of the Constitution, the following law and sub-decree have been issued:

a. No. Nordom Sihanouk-Royal Decree - 0196-21 dated January 24, 1996 on the establishment of the Ministry of Environment

b. 57 Sub-Decree on the organization and functions of the Ministry of Environment, RGC was issued and entered into force in 1997.

c. Others in connection with environmental considerations

Table 2.1.1 shows a list of environmental laws, decrees, sub-decrees, regulations and guidelines having been established and issued in Cambodia. Figure 2.1.1 shows the protected areas in Cambodia. The protected areas include national parks, natural sanctuaries and protected forests.

Table 2.1.1 List of Environmental Regulations in Cambodia

1.	Article 59 of the Constitution of the Kingdom of Cambodia
2.	Royal Decree on the Protection of Protected Areas
3.	Royal Decree on The Establishment and Management of Tonle Sap Biosphere Reserve
4.	Law on Environmental Protection and Natural Resources Management
5.	Sub-Decree on the Organization and Function of the Ministry of Environment
6.	Sub-Decree on Environmental Impact Assessment Process
7.	Prakas (Declaration) on Guideline for Conducting Environmental Impact Assessment Report
8.	Guidelines for Conducting Environmental Impact Assessment (EIA) Report
9.	Sub-Decree on Water Pollution Control
10.	Sub-Decree on Solid Waste Management
11.	Sub-Decree on Air and Noise Pollution Control
12.	Prakas (Declaration) No. 1033 on Protected Areas
13.	Annex to Prakas No. 1033
14.	Drafted Decree on the Establishment and Management of Protected Areas

Source: MOE

Table 2.1.2 shows the names, areas and provinces of the protected areas.

Figure 2.1.1 Protected Areas and Small Scale Potential Hydropower Sites in Cambodia

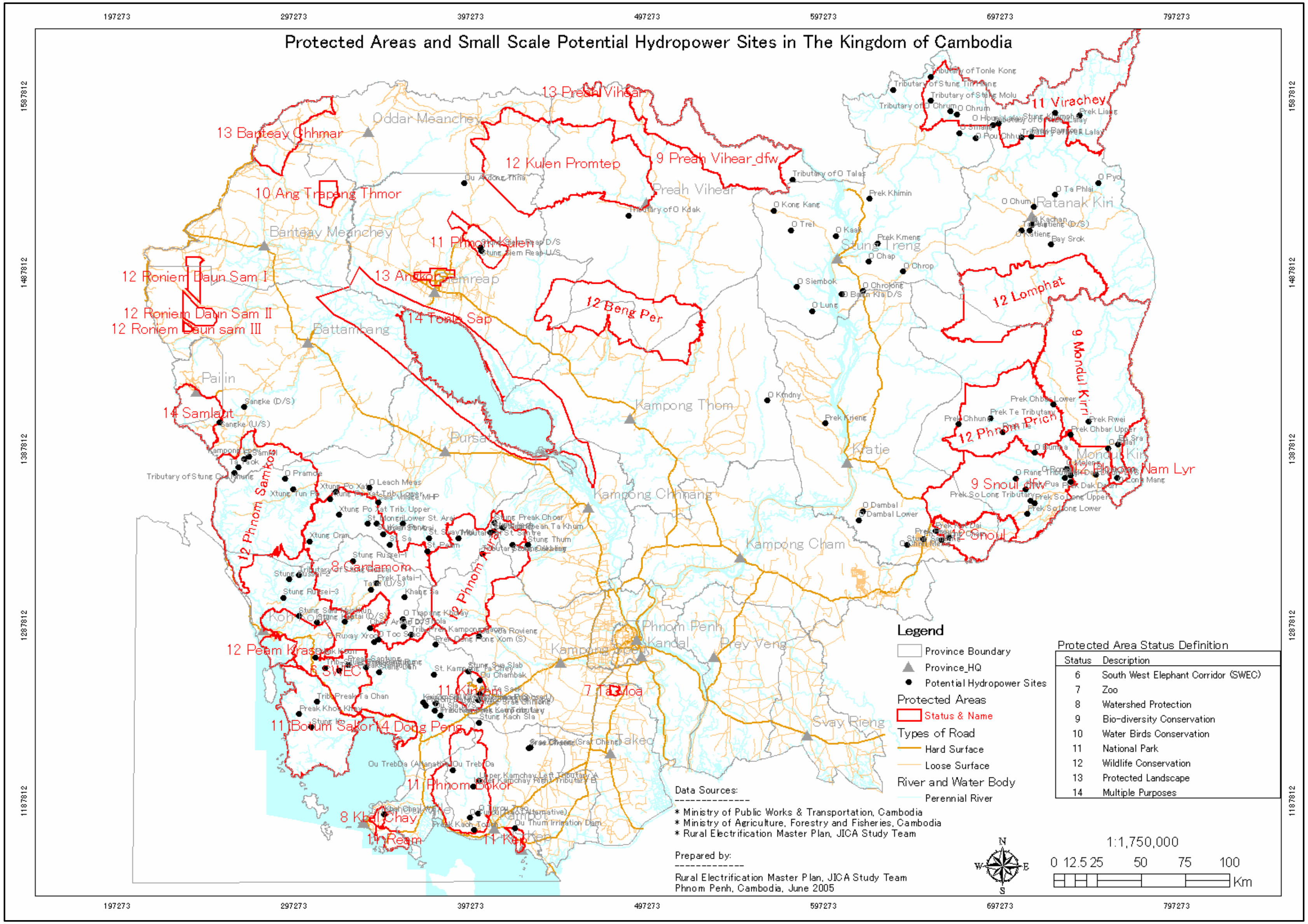


Table 2.1.2 List of National Parks, Wildlife Sanctuaries, Protected Landscapes and Others in Cambodia

(Specified under the Royal Decree on the Protection of Protected Areas, November 1, 1993)

No.	Names of the Protected Areas	Land Area Covered (ha)	Provinces Where the Protected Areas are Located
I. National Parks			
1	KIRIRUM	35,000	Kampong Speu and Koh Kong
2	BOKOR	140,000	Kampot
3	KEP	5,000	Kampot
4	REAM	150,000	Sihanouk Ville
5	BOTUM SAKOR	171,250	Koh Kong
6	PHNOM KOULEN	37,500	Siem Reap
7	VIRAK CHEY	332,500	Stung Treng and Rattanak Kiri
II. Wildlife Sanctuaries			
8	PHNOM ORAL	253,750	Koh Kong, Pursat, Kampong Chhnang
9	PEAM KRASOP	23,750	Koh Kong
10	PHNOM SAMKOS	333,750	Koh Kong
11	RONEAM DONSAM	178,750	Battambang
12	KOULEN PRUM TEP	402,500	Siem Reap and Preah Vihear
13	BENG PER	242,500	Kampong Thom
14	LUMPHAT	250,000	Rattanak Kiri and Mundul Kiri
15	PHNOM PRICH	222,500	Mundul Kiri and Kratie
16	PHNOM NAMLEAR	47,500	Mundul Kiri
17	SNUOL	75,000	Kratie
III. Protected Landscapes			
18	ANGKOR	10,800	Siem Reap
19	BANTEAY	81,200	Banteay Mean Chheay
20	PREAH VIHEAR	5,000	Preah Vihear
21	DONG PENG	27,700	Koh Kong
22	SAMLOT	60,000	Battambang
23	TONLE SAP	316,250	Kampong Chhnang, Kampong Thom, Siem Reap, Battambang and Pursat

Source: MOE

Terminology :

National Park : Areas reserved for nature and scenic views to be protected for scientific, educational and entertainment purposes.

Wildlife Sanctuary : Natural areas preserved at their natural conditions in order to protect wildlife, vegetation and ecology balance.

Protected Landscapes : Areas to be maintained as scenic views for pleasure and tourism.

Multiple Use Areas : Areas necessary for the stability of water, forestry, wildlife, and fisheries resources, for pleasure, and for the conservation of nature with a view of assuring economic development.

(i) Mission and Functions of the Ministry of Environment

Article 2 of the No.57 Sub-Decree gives the Ministry of Environment (MOE) the mandate to supervise and manage the environmental sector throughout Cambodia.

The MOE has the following functions:

- to implement environmental policies to ensure sustainable development of the country;
- to develop and implement environmental legal instructions to promote and ensure sustainable development of the country;
- to review and make recommendations on environmental impact assessments of proposed and current public and private sector projects and activities;
- to provide guidance to concerned ministries to ensure the conservation, development, management and utilization in a rational and sustainable manner of the natural resources, which are defined in Article 59 of the Constitution;
- to manage the national protected areas as demarcated in the Royal Decree dated November 1,

1993 on the creation and designation of protected areas;

- to inventory sources, types and quantities of all the solid and liquid wastes, pollutants, toxic and hazardous substances, emissions, noise and vibration, and to propose measures to prevent, reduce and control environmental pollution in collaboration with concerned ministries;
- to enforce laws as described in ***Chapter 9*** of the Law on Environmental Protection and Natural Resource Management;
- to collect, analyze and manage environmental data and prepare an annual state of the environment report;
- to develop and implement environmental education programs among all the sectors;
- to develop proposals for RGC to join international agreements, conventions and protocols on environmental protection and to carry out those technical tasks necessary for RGC to meet its commitments and responsibilities under such agreements, conventions and protocols;
- to promote investment in environmental protection and natural resources conservation, and to organize and manage an environment endowment fund for these objectives;
- to collaborate with national and international organizations, NGOs, local communities, and other countries to promote environmental protection in Cambodia. (ii) Organization of the MOE

(ii) Organization of the MOE

The organization of MOE has been structured as shown below:

a. Central level

- Cabinet of the Minister
- Office of Inspection
- General Directorate
  - i) Department of Planning and Legal Affairs
  - ii) Department of Nature Conservation and Protection
  - iii) Department of Pollution Control
  - iv) Department of Natural Resources Assessment and Environmental Data Management
  - v) Department of Environmental Education and Communications
  - vi) Department of Environmental Impact Assessment Review
- Department of Administration and Finance

b. Provincial level

- Provincial and Municipal Departments of Environment

  Each province or provincial municipality has a provincial/municipal department of environment, and each district/khand (Phnom Penh district) has a district/khand agency of environment. These departments and agencies are responsible for coordinating and implementing MOE activities in their respective provinces, town, district and khand.

(iii) Sub-Decree on Environmental Impact Assessment Process

No.72 ANRK.BK “Sub-Decree on Environmental Impact Assessment Process” was issued on August 11, 1999, which has stipulated the requirements of conducting Initial Environmental Impact Assessments (IEIA) and/or EIAs, involvement of MOE in review and approval of the IEIAs and/or

EIAs, and public participation in the EIA process. Annex of this Sub-Decree provided a list of the projects requiring EIAs. It is required that project proponents shall carry out an IEIA and or EIA for their proposed various projects and activities, including those for electric power generations in the country.

For the case of power generation projects, project proponents shall carry out EIA as required by the Sub-Decree, if a power plant has an installed capacity ≥ 5 MW for thermal power and ≥ 1 MW for hydropower. Project proponent shall first carry out IEIA and prepare an IEIA Report. The report shall be submitted to MOE for its review and comments. If MOE deemed a full EIA must also be implemented, then the project proponent shall carry out the EIA and submit the EIA report to MOE for its review, comments and approval.

If the capacity of a proposed hydropower project is smaller than 1 MW, no specific requirements will be imposed on the project proponent regarding environmental assessment activities.

Therefore, in the case of micro hydro (< 500 kW) and other renewable power generation (as far as its capacity is smaller than 5 MW), no specific environmental assessment activities would be required. However, it is important to pay attention to environmental considerations in any case of the capacity. The following are some points of concerns to be considered for such cases:

- the extent of tree logging intentions/desires of concerned villagers in the case of biomass power;
- possible scenic effect to the flow of waterfalls in the case of micro hydro; and
- possible conflict with intentions/desires of concerned villagers.

(iv) A new Decree on Reformation of Environmental Regulatory System

A new Decree has been enacted since June 2005 to reform the environmental regulatory system. Key points of the new Decree stipulated in connection with the process of conducting EIAs are summarized below.

a. If the total amount of funds to be invested for a development project will be equal to or higher than US$ 2 Millions, the project will be subject to the approval of Cambodia Development Council (CDC) of RGC. CDC will be co-chaired by Prime Minister and President of Parliament. The MOE is responsible for environmental regulations as stipulated by the related Decrees and Sub-Decrees to date. The Process of carrying out IEIA and/or EIA and the approval system are kept unchanged.

b. If the total amount of funds invested for a development project will be less than US$ 2 Millions, Provincial government (the Governor) will have the authority to enforce the environmental regulatory system for such projects. Such projects will be subject to the approval of Provincial Sub-committee of Development, which will be chaired by the Governor. Provincial and Municipal Departments of Environment will be responsible for review and approval of an IEIA and/or EIA Reports prepared the project proponents.

c. Any project, which will be located in a Protected Area, will be subject to the approval of the MOE.

d. In any cases of the above, The MOE will be responsible for environmental management and monitoring activities to be needed for a project operation.

(2) Accumulative Potential Environmental Impacts

(i) Current Electricity Supply Capacity in Cambodia

Based on the documents of Cambodia's "Renewable Electricity Action Plan – An Investment Guide for Renewable Electricity Development"(First edition, May,2003) and "Cambodia Energy Strategy" (MIME, January 2005), current total installed capacity are estimated as listed below:

a. EDC 87 MW
b. IPPs 57 MW
c. REE 60 MW
c. Self-generators 116 MW
e. Hydropower 13 MW
f. Solar photovoltaics 0.2 MW
g. Imported power 20 MW
h. Estimated total 353 MW

Most of the power are supplied by diesel generators. There are two hydropower stations as described in Section 5.1 of Part 1.

Either IEIA or EIA was not conducted for the existing two hydropower plants. Through field survey carried out for O Chum II in January 2005, it is judged that there has been no significant environmental impacts in and around the site except that trees were cut down during construction of intake weir for creating the reservoir.

Due to no EIA data available, it is not possible to discuss on the accumulative environmental impacts caused by the two hydropower plants and diesel generators. Total power capacity of existing diesel generators is more than 300 MW as of 2004, of which one third is shared by small generators of REE or own generators. Because the total capacity of existing solar photovoltaic power plants is very small, their environmental impact is judged negligible.

(ii) Accumulative Potential Environmental Impacts

Accumulative potential environmental impacts means the total potential environmental impacts which would be caused by implementing all the rural electrification projects as proposed in the Master Plan. The impacts include both 1) accumulative impacts on the natural environment, and 2) accumulative impacts on the social environment.

1) Micro/pico Hydro

For purposes of discussion in this section, hydropower schemes are classified into five groups as described in Section 5.1 of Part 1. According to the study and reconnaissance conducted in December 2004 and January 2005, of the five groups only micro hydro (< 500 kW) can practically be candidates for rural electrification in the off-grid areas. Mini hydro (500-5,000 kW) and larger schemes can be developed only for on-grid electrification because of sharp drops in the dry season flow and output in Cambodia.

The following insights can be derived regarding the potential environmental impacts of the hydropower projects:

a. There will be no potential and no accumulative environmental impacts to be caused by installing a pico-hydro equipment.

b. Micro hydro having a capacity in a range of 1-100 kW will have very little environmental impacts, if proper mitigation measures are taken. The potential environmental impacts foreseen are:

i) A flat land area of some 200-400 m^2 may be needed for installing a power house.

ii) Removing several trees for constructing headrace channel, penstock and power house might be needed.

The above potential impacts can be mitigated and, therefore, there will be no accumulative environmental impacts for such cases.

c. Micro hydro having a capacity in a rage of 100-300 kW may have some potential environmental impacts, for which mitigation measures will have to be properly taken. The potential environmental impacts will be:

i) A flat land area of more than 400 m^2 may be needed for installing a power house. This might incur resettlement of a few households.

ii) Removing tens of trees for constructing headrace channel, penstock and power house might be needed.

iii) It may affect a scenic view of waterfalls if a head of the waterfalls is used.

The above potential impacts must be mitigated as noted below:

i) If some resettlements are needed, an appropriate resettlement plan is to be prepared. Resettlement issue must be solved by reflecting opinions and desires of project-affected-people (PAP) including compensations if required.

ii) Replanting the removed trees in a proper area, or planting the same number or more of new trees in appropriate areas.

iii) If it is planned to develop a head of waterfalls, the waterfalls shall be neither a tourism spot nor a candidate site planned by local government or other stakeholders. If it affects such tourism, mitigation measures should be studied such as to reduce the power generation during daytime or to use the river flow only during the nighttime for lighting. In any case, prior consultations with concerned central and local governments and stakeholders shall be held to seek for their opinions and agreement. Without their agreement, such hydropower projects shall not be implemented.

Use of waterfalls is the most sensitive from viewpoint of natural conservation. Careful planning is needed.

2) Photovoltaic Power

There are many existing PV applications in the country. Their capacities are from 40 Wp to 5 kWp, except for telecommunications (MobiTel: 127 kWp). PV power cannot stand alone without batteries and/or backup by diesel generator.

The study will be limited to PV applications having capacities up to 10 kWp with batteries. As shown in Table 5.3.2 of Part 1, the planned capacity of solar BCS for rural electrification in the off-grid area is in a range of 1 to 4 kWp. For such scale, no or only minor environmental impacts would be caused. The basis of the insight is given below:

i) The open space needed can be easily arranged without cutting trees.

ii) No pollution will be generated by the PV system, except an issue of waste batteries.

iii) No social environmental impacts will be incurred.

Therefore, the accumulative potential environmental impacts to be caused by all the PV projects will be minor and negligible. However, the waste issue of used batteries exists in residential area including the capital city, provincial cities and villages, where batteries are used as a power source. It will be discussed in the following section in more details.

3) Wind Power

Little data on surface wind are available in Cambodia. Batteries are prerequisite for wind power systems for rural electrification in the off-grid area. Because of the low wind potential in Cambodia and the requirement of station batteries, a wind power system has been excluded from candidate energy sources for the rural election in the off-grid area.

Hybrid system with PV power can be considered. In the case of kW class wind turbine combined with PV, there will be no environmental impacts.

4) Biomass Power

a. Biomass combustion power plants

Biomass as a burning fuel for power plants has no SO_x generation. Reduction of NO_x from exhaust gas should be considered. For small scale plants having capacity less than 1 MW/unit, accumulative environmental impacts will be not significant. The biomass combustion power has been excluded from candidates for the rural election in the off-grid area because of its large scale not suitable for village electrification and the technology level required for operation and maintenance of boiler system.

b. Biogas Power Plants

If biogas is utilized for power generation, potential environmental impacts will be lower than biomass combustion plants. In addition, biogas has been excluded from candidates for the rural election in the off-grid area because of little potential except for individual household system for cooking energy supply.

c. Biomass Gasification Power Plants

If biomass is gasified for power generation by gas engine, potential environmental impacts will be lower than biomass combustion plants. A potential environmental issue is illegal logging of forests nearby a biomass plant. The issue may arise if the planned biomass supply for plant operation falls insufficient due to various reasons. To avoid such situation, it has been planned to cultivate fuel woods in farmland nearby and not to buy from open markets. In the case of using agricultural wastes as fuel such as rice husk, rubber trees, and so forth, fuel supply should be secured by agreement with such waste disposers. The deforestation issue, if taken place, would become a significant environmental impact.

(3) Treatment and Disposal of Used Batteries

(i) Present status of Treatment and Disposal of Used Batteries

Through interview surveys carried out in Phnom Penh and villages in Ratanak Kiri Province in

January 2005, the following present situation are known:

a. There are specialized dealers collecting used batteries. The collecting services are provided as a business.

b. The collected batteries will finally be transported to Thailand or Vietnam for recycling processing.

c. No processing and recycling business exists in the surveyed areas except for disassembling and classifying of battery components by type of materials.

(ii) Treatment and Recycling Methods of Used Batteries

1) Introduction

A battery cell (2.1 V to 2.2 V when fully charged) is composed of the following components:

a. Electrodes

b. Cathode plates: lattice type base plates for pasting lead (Pb)

c. Anode plates: lattice type base plates for pasting lead dioxide (PbO_2)

d. Electrolyte: sulfuric acid liquid with low concentration (Specific gravity is about 1.28 when fully charged, and will be about 1.12 when full discharged.)

e. Separator membrane: made of synthetic resin together with pulp fibers

f. A casing to contain the above to form a cell.

Chemical reactions of discharging and charging process are as shown below:

a. Discharging reaction

1) Cathode plate

$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$

2) Anode plate

$PbO_2 + 2H^+ + 2e^- \rightarrow PbO + H_2O$

$PbO + 2H^+ + SO_4^{2-} \rightarrow PbSO_4 + H_2O$

b. Charging reaction

1) Cathode plate

$PbSO_4 + 2e- \rightarrow Pb + SO_4^{2-}$

2) Anode plate

$PbSO_4 + 2H_2O \rightarrow PbO_2 + 4H^+ + SO_4^{2-} + 2e-$

In general, a 12 V or 6 V batteries can be repeatedly used for long-term by charging. However, due to the following factors, the batteries can only be useful for a few years:

a. Degradation of electrodes, cathode and anode plates in the cells, etc.

b. Damage to battery casings

c. Over discharging and over charging

d. Others

2) Treatment and Recycling Methods

The methods are described here for lead-acid batteries of 12 V or 6 V. Batteries with higher voltages need some other special treatments:

a. Collection of used batteries for recycle

b. Recycle treatment for the components of batteries

1) Disassembling batteries into components

2) Melting degraded cathode and anode plates

3) Extracting pure Pb and make it into pure Pb ingots

4) Neutralization treatment of sulfuric acid liquid

5) Incineration of burnable wastes

6) Recycle Pb ingots for manufacturing new batteries

7) Proper disposal of wastes generated from the treatment processes above

Figure 2.1.2 shows a process flow of the battery recycling:

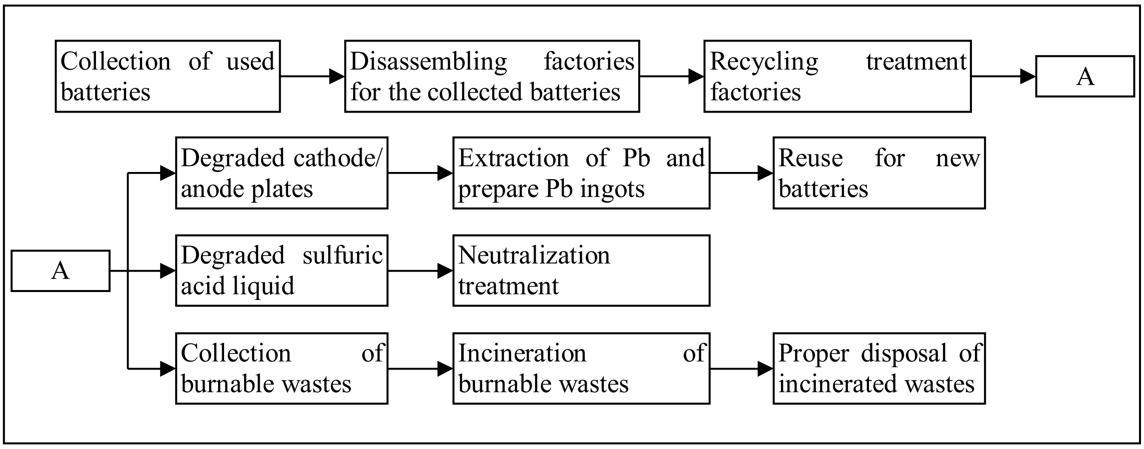


Figure 2.1.2 Process Flow of Recycling Used Batteries to be Disposed

(4) Information on CDM Projects in Cambodia

(i) Present status of CDM Projects

1) Administrative Structure and Requirements

The Prime Minister's Decision No. 01 dated July 15, 2003 stipulates the following items in connection with the CDM in Cambodia:

a. The MOE has been appointed as the Designated National Authority (DNA) for the CDM.

b. DNA Board will be composed of the representatives from MOE, MAFF, MIME, MOP, CDC and MPWT. The Board will have three Technical groups; "Energy Technical Working Group", "Forestry Technical Working Group", and "other". The "other" will be decided as needed.

c. MOE, as the DNA, will have the authority to request information from CDM project proponents, concerned agencies and stakeholders.

d. MOE shall develop a set of interim criteria suitable to assess the proposed CDM projects.

e. MOE will assess the proposed CDM projects based on the sustainable development criteria. A draft "Sustainable Development Criteria" (SDC) has been proposed.

f. MOE has the other responsibilities and authorities as needed for the CDM projects.

2) Progress Status of the CDM Project Activities

Progress status of the CDM projects as of October 2004 is as summarized below:

Three CDM feasibility studies were completed

i) Marubeni Corporation Study – 7,600 ha rubber plantation project

- Acquirement of carbon credit every 5 years since the 11 years after the project initiation (as cited below)
- 39,377 t-CO_2 in 2015, 642,051 t-CO_2 in 2020, 1.5 million t-CO_2 in 2025, 2.32 million t-CO_2 in 2030, and 2.9 million t-CO_2 in 2034

ii) Japan Waste Foundation Study – Methane capture at Phnom Penh waste dumpsite

- A F/S on greenhouse effect reduction and energy exploitation business through recovery of methane gas generated from waste disposal sites in Phnom Penh
- Cumulative amount of GHG to be recovered is about 279,300 tons (CO2 equivalent)

iii) NEDO Study – 70 kW hybrid micro-hydro/solar

- Independent mini grid powered by PV-micro-hydro hybrid system in Kampong Cham Province
- GHG emission reduction is about 302 t-CO_2 eq./year

a. CDM feasibility studies under development

   i. Marubeni Corporation Study – for dissemination of 115 micro-wind/hydro schemes (total installed capacity up to 1.4 MW)

   ii. Angkor K.R. Co. – Rice husk co-generation 1.5 MW

b. Projects under development

   i. Cetic International – Mini-hydro 13 MW

   ii. Mai wood waste – 10 MW wood waste rehabilitation

   iii. MOE and concerned ministries are soliciting investors in 2005 for the CDM projects, of which F/S has been completed.

3) Possibility of Application of CDM to Rural Electrification

Both of the NEDO F/S (70 kW hybrid micro-hydro/solar system) and ongoing Marubeni F/S (a hybrid system of micro wind/hydro power project) are studied as potential CDM projects and aimed at providing electricity to rural areas. It is possible to apply CDM to the rural electrification. The key issue will be to have investors for such RE projects.

(ii) Small-scale CDM Project Activities and a Bundled SSC Project Activity

Definition of a Small-scale CDM (SSC) project activity has been given by the CDM Executive Board (the EB or CDM-EB), which includes the following three types of project activities:

Type (i): Renewable energy project activities with a maximum output capacity equivalent up to 15MW. Renewable energy sources from solar, wind, hybrid system, biogas or biomass, water, geothermal and waste belong to this category.

Type (ii): Energy efficiency improvement project activities which reduce energy consumption by up to the equivalent of 15 GWh/year.

Type (iii): Other project activities that both reduce anthropogenic emissions by sources and directly emit less than 15 kilotonnes of CO_2 equivalent annually.

On the other hand, a number of SSC project activities may be bundled into one SSC project activity, if the size of the total bundled capacity will not exceed the definition of SSC project activities as mentioned above.

The following simplified modalities and procedures can be applied to the SSC project activities:

1) The requirements for the Project Design Document (PDD) are reduced. Details are given by the *Appendix A* to the Simplified Modalities and Procedures for SSC Project Activities: "CDM Simplified PDD for Small Scale Project Activities (SSC-PDD)", Version 1 (21 January 2003).

2) Simplified baseline and monitoring methodologies have been developed for the SSC project activities.

From the above, it is clear that modalities and the procedures of the SSC project activities defined by the CDM-EB will be applicable to the renewable energy projects being studied and developed under the Master Plan Study. Details of the steps of a CDM project cycle, including those for SSC cases, can be found from relevant documents, such as CDM M&P (Annex to Decision 17/CP.7) and others.

2.1.2 Environmental Screening of Prospective Micro Hydro Projects

The following five MHP have been selected temporarily as the prospective MHP projects:

1) Bay Srok MHP project (in Rattana Kiri Province)
2) O Phlai MHP project (in Mondul Kiri Province)
3) Sangke (U/S) MHP project (in Battambang Province)
4) Sangke (D/S) MHP project (in Battambang Province)
5) Tatai (D/S) MHP project (in Koh Kong Province)

(1) Results of Environmental Screening of "***Bay Srok***" MHP

Table AP-D.1.4 of **Appendix-D** shows the results in the form of "Environmental Screening Format". Key points of the results are summarized below.

a. The candidate project site will be located outside of any "Protected Area".
b. The MHP will utilize the head difference of the O Sien Ler Waterfall having seven (7) cascades existing along O Sien Ler River. The location is in the area of Bay Srok Village, Bay Srok Commune, Rattana Kiri Province.
c. The 7 cascades waterfall is under the management of "Provincial Rural Development Committee (the Committee). The waterfall is a tourism spot.
d. Therefore, carrying out IEIA is recommended. The IEIA must be approved by the Provincial authority.

e. Stakeholders meeting shall be held at various stage from the project planning to reflect opinions and comments concerned parties, especially those of the villagers and the Committee.

f. During dry season, operations of the MHP will be limited to night time to mitigate impacts to the tourism. The operational scheme shall be accepted by the parties concerned.

g. The area of Bay Srok village and its vicinity is a place having gem stone resource. Collection and processing of gem stones are trhe major income sources of the villagers. As of January 2005, average income amount per household here is about 150,000 Riel (US$38) which is much higher than that of other villages in the Province. Therefore, population of the village is increasing, which causes electricity demand also being increased.

(Remarks: For details of the social-economic conditions of the village, refer to a separated document "The Results of Interview and Field Survey of Bay Srok MHP Project Candidate Site".)

(2) Results of Environmental Screening of "***O Phlai***" MHP

Table AP-D.1.5 of **Appendix-D** shows the results in the form of "Environmental Screening Format". Key points of the results are summarized below.

a. The project site will be located on the boundary of a Wildlife Sanctuary called Pham Nam Lyr designated in the Mondul Kiri Province. Therefore, Initial Environmental Impact Assessment will be required.

b. It is intended to supply the installed power only to Bu Sra Commune. This may cause problem with the villagers living in the Sre Om Pum Commune. The generated power should also be supplied the Sre Om Pum where the MHP will be located.

c. Stakeholders meeting shall be held at various stage from the project planning to reflect opinions and comments of concerned parties, especially those of the villagers. It should be noted that most of the people living in this area are minorities (more than 90%).

Remarks : For details of socio-economic conditions and others of the Sre Om Pum Commune, refer to a separated document "The Results of Interview and Field Survey of O Phlai MHP Project Candidate Site".

(3) Results of Environmental Screening of "***Stung Sangke (D/S)***" MHP

Table AP-D.1.6 of **Appendix-D** shows the results in the form of "Environmental Screening Format". Key points of the results are summarized below.

a. The project site will be located outside of any Protected Area.

b. Therefore, only the Environmental Screening Report would be needed for getting project approval from the Provincial Authority (Battambang Province).

c. Stakeholders meetings shall be held at various stage from the project planning to reflect opinions and comments of concerned parties, especially those of the villagers.

d. It should be noted that land mine cleaning will be required before carrying out any field surveys.

(4) Results of Environmental Screening of "***Stung Sangke (U/S)***" MHP

Table AP-D.1.7 of **Appendix-D** shows the results in the form of "Environmental Screening Format". Key points of the results are summarized below.

a. The project will be located on the boundary of Samlot Protected Area (Protected Landscapes in Battambang Province). Therefore, carrying out IEIA will be required. The IEIA report will be subject to review and approval by the MOE.

b. Stakeholders meetings shall be held at various stage from the project planning to reflect opinions and comments of concerned parties, especially those of the villagers.

c. It should be noted that land mine cleaning will be required before carrying out any field surveys.

(5) Results of Environmental Screening of "***Stung Tatai (D/S)***" MHP

Table AP-D.1.8 of **Appendix-D** shows the results in the form of "Environmental Screening Format". Key points of the results are summarized below.

a. The project site will be located outside of any Protected Area. Therefore, only the Environmental Screening Report would be required for submitting to the Provincial Authority for project approval. (Koh Kong Province)

b. Stakeholders meetings shall be held at various stage from the project planning to reflect opinions and comments of concerned parties, especially those of the villagers.

2.1.3 A Guide to Environmental and Social Considerations for Rural Electrification Projects

This guide (the Guide) is prepared for applying to rural electrification projects in Cambodia. The Guide contains not only the environmental requirements stipulated by the MOE of RGC, but also those of foreign government and international funding organizations, such as the World Bank (WB) and Asian Development Bank (ADB). It is noted that most of the guidelines introduced from foreign or international requirements have been simplified to avoid unnecessary confusions. In addition, the Guide has put emphasis on the philosophy and methodology of conducting IEIA and/or EIA.

Considering the sources of funds to be used, there will be three cases of rural electrification projects as listed below.

Case I : The project(s) which will be funded entirely by domestic funding sources.

Case II. : The project(s) which will be partially or entirely funded by foreign private funding sources.

Case III.: The project(s) which will be partially or entirely funded by foreign governments and/or international organizations such as World Bank or ADB.

For the **Case I** projects which will be funded entirely by domestic funding sources, only the Environmental laws, and relevant Decrees/Sub-Decrees of the RGC will be applicable.

For the **Case II** projects which will be partially or fully funded by foreign private funding sources, especially for those to be applied to the Clean Development Mechanisms Executive Board (CDM-EB) as a CDM project for dealing the Green House Gas (GHG) emission reduction, not only the environmental regulations of the RGC, but also those of investor's country may be applicable to such projects. For this case, it is required to consult with concerned Designated Operational Entity (DOE) in advance.

For the **Case III** projects which will be partially or fully funded by foreign government and/or international funding organizations, both of environmental regulations of the RGC and those of foreign government and/or international funding organizations will be applicable.

The JICA's environmental guidelines named as "JICA Guidelines for Environmental and Social Considerations" (April 2004) are applicable to all grant projects of the Government of Japan (GOJ). Those guidelines of WB and ADB are applicable to their funded projects. However, the highest priority shall be given to all the relevant requirements of the environmental laws and regulations of the MOE of Cambodia.

In order to avoid uncertainties and possible hesitations to be incurred in carrying out an IEIA and/or EIA of proposed projects, the Guide introduced here is discussed in the following paragraph (2). The Guide includes the processes of environmental considerations for the above three cases. It is noted here that some of the guidelines introduced from foreign or international requirements are simplified to avoid unnecessary confusions. In addition, the Guide has reflected the environmental regulatory system reformed by the current new Decree as mentioned in Section 2.1.1 above. Figure 2.1.3 shows the process of classification of these three cases.

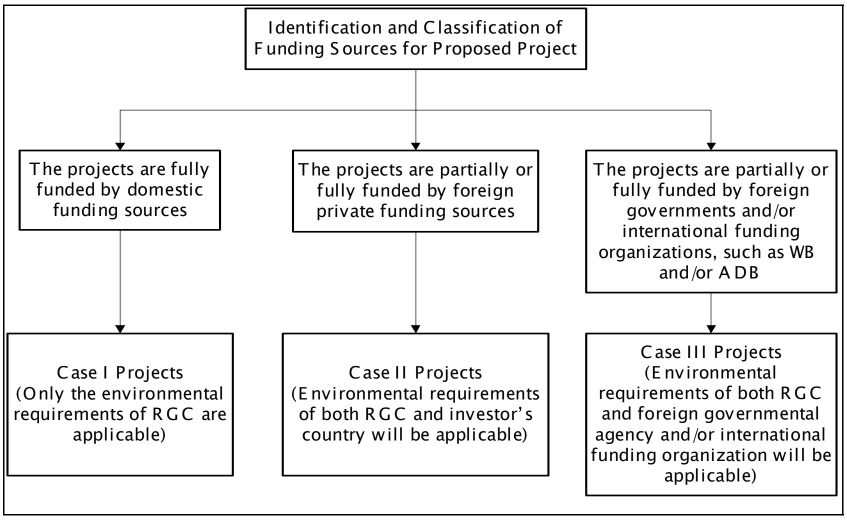


Figure 2.1.3 Classification of Proposed Projects Based on Funding Sources

(2) The Guide to Environmental and Social Considerations for Rural Electrification Projects

(2)-1 General Terms

a. All the environmental regulations of RGC as stipulated by the Laws and Sub-Decrees shall be applicable to all the proposed development projects and activities. The highest priority shall be given to these requirements.

b. In principle, information about environmental and social considerations of proposed projects will be disclosed to concerned stakeholders by the MOE, concerned Provincial Government and project proponents at each stage of the project planning, environmental assessment and project implementation. Information disclosure to local stakeholders is intended to take local environmental and social factors into considerations in the most suitable way. For this purpose, stakeholder meetings shall be held.

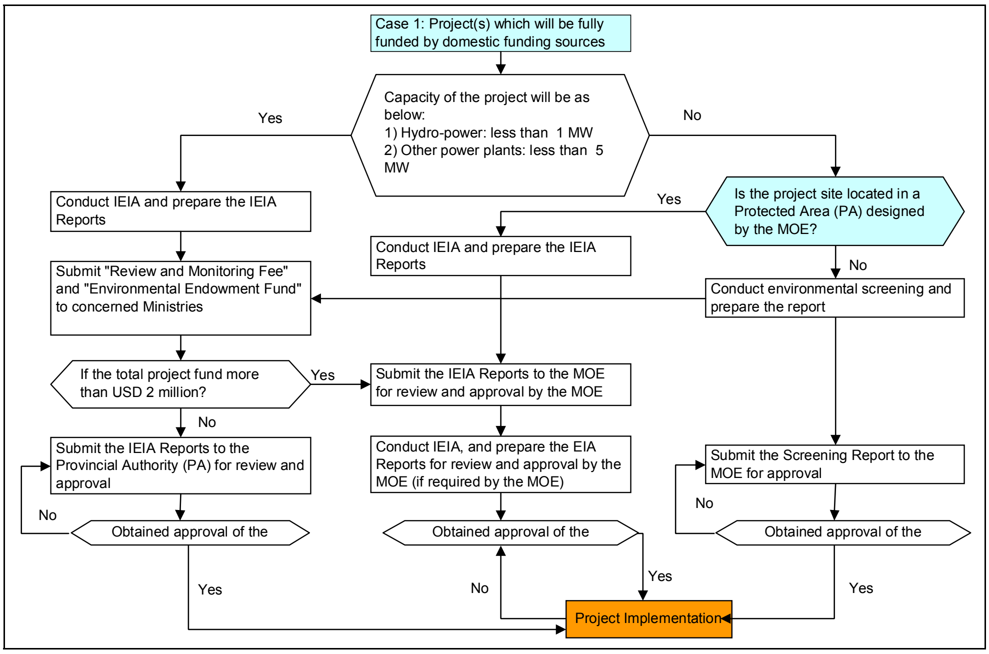
c. The results of consultations made with stakeholders shall be reflected to proposed project design and IEIA/EIA as needed by the MOE.

d. If the total amount of funds to be invested for a project will be less than US$ 2 Millions, the concerned Provincial Government will have the authority of environmental regulations.

(2)-2 The Guide for **Case I** Projects

For the **Case I** projects, which will be funded completely by domestic funding sources, only the Environmental Laws, and relevant Decrees/Sub-Decrees of the RGC will be applicable. It is noted that Articles 11 and 12 of Sub-Decree No.72, ANRK.BK dated August 11, 1999 regarding the Environmental Review and Monitoring Fee, and Environmental Endowment Fund shall be prepared and submitted by the project proponents to the related Ministries.

Figure 2.1.4 shows the Process of Conducting IEIA and/or EIA for **Case I** Projects.



Source: JICA Study Team

Figure 2.1.4 The Process of Conducting an IEIA and/or EIA for Case I Projects

(2)-3 The Guide for **Case II** Projects

For the **Case II** projects, which will be funded completely by foreign private funding sources, there will be 2 sub-cases as below.

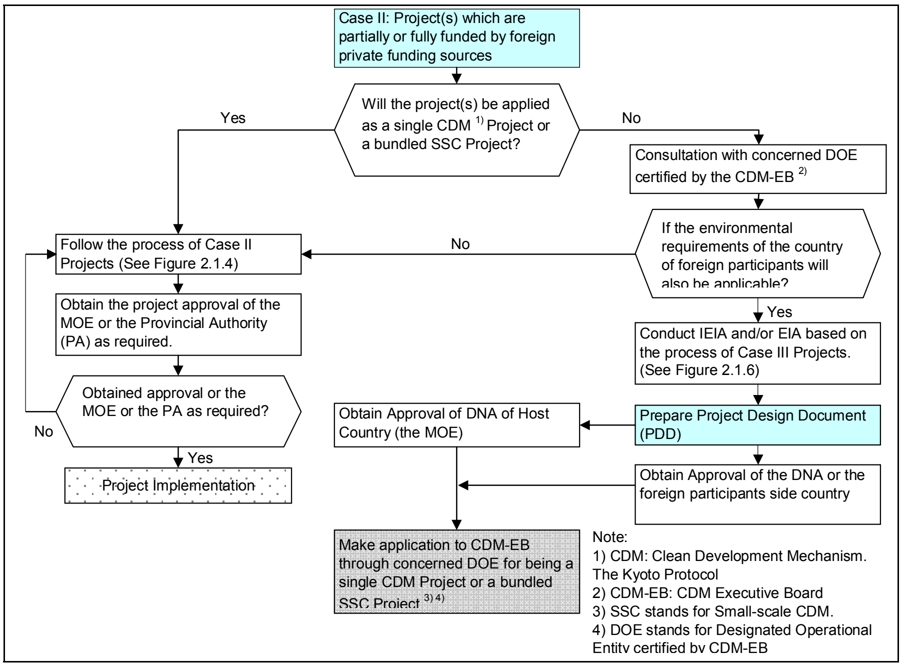
Sub-case 1 : The projects will not be applied as a CDM project for GHG emission reduction for the private foreign funding sources.

Sub-case 2 : The projects will be applied as a CDM project for GHG emission reduction for the private foreign funding sources.

For the **Sub-case 1**, only the Environmental Laws, and relevant Decrees/Sub-Decrees of the RGC will be applicable. The “Environmental Review and Monitoring Fee”, and “Environmental Endowment Fund” shall be prepared and submitted by the project proponents to the related Ministries as required by Articles 11 and 12 of Sub-Decree No.72, ANRK.BK dated August 11, 1999.

For the **Sub-case 2**, consultation with concerned Designated Operating Entity (DOE) will be needed to confirm if the environmental requirements of the investors' countries will also be applicable.

Figure 2.1.5 shows the Process of Conducting IEIA and/or EIA for **Case II** Projects.



Source: JICA Study Team

Figure 2.1.5 The Process of Conducting an IEIA and/or EIA for Case II Projects

(2)-4 The Guide for **Case III** Projects

Based on the requirements of CDM-EB, it is noted that the **Case III** Projects are not allowed to be the CDM projects. Figure 2.1.6 shows the Process of Conducting an IEIA and/or EIA for the **Case III**.

The following are the details of the process of conducting an IEIA and/or EIA for the **Case III** projects:

(i) Carrying out Environmental Screening for Proposed Project

a. Study on components and rationale of proposed project

b. Carry out environmental screening for proposed project

An environmental screening format (refer to Table AP-D.1.2 of **Appendix-D**) shall be used to clarify characteristics of proposed project. The results of environmental screening will be used as the basis of categorizing proposed projects. This is also a check list.

c. Categorization of proposed projects

The proposed project shall be categorized based on the requirements as explained herein below. Both Category I or II (based on the requirements of RGC) and Category A, B or C (based on the requirements of foreign governmental agency and/or international funding organizations) shall be identified.

The results of environmental screening will be used also for environmental scoping of proposed projects.

(ii) Categorization of Proposed Projects

Based on the results of Environmental Screening, each proposed project will be categorized by the following two ways:

1) Categorization based on the guidelines of RGC

a. Category I projects (not relevant to Master Plan projects)

i) "Annex of **Sub-Decree No.72** ANRK. BK (August 11, 1999) on Environmental Impact Assessment Process" provides a "List of the Projects Require an IEIA or EIA". Article 6 of the Sub-Decree stipulates "The project owner shall provide a report on IEIA of the project where EIA is required in accordance with the annex of this sub-decree."

ii) Based on Articles 15 and 16 of the Sub-Decree, IEIA report shall be prepared by the project proponents during pre-feasibility study and submitted to MOE. If the MOE requires a full EIA report, the project proponents must conduct the full EIA during the feasibility study, and submit the EIA report to the MOE.

b. Category II projects (relevant to all the Master Plan projects)

Proposed projects with capacities smaller than the limits specified in the Annex belong to this category. All the rural electrification schemes as proposed in the Master Plan are classified to this category such as micro hydro smaller than 500 kW, biomass gasification power of 10 to 500 kW class, PV and solar BCS up to 10 kWp class.

In principle, an IEIA and/or EIA will not be required for such project. However, environmental screening will be needed to ensure that potential environmental impacts be minimum or negligible. The results of the environmental screening shall be submitted to MOE for its review and comments. If MOE deems need of an IEIA, the project proponents shall carry out an IEIA and submit it to MOE for review, comments and approval.

2) Categorization Based on JICA/WB/ADB Requirements

a. Category A projects

(The projects which will be located in a "sensitive area".)

The projects are likely to have significant adverse impacts (see Table AP-D.1.1 of **Appendix-D**). A full scale EIA will be needed and its EIA report shall be submitted to the MOE for review, comments and approval.

b. Category B projects

(The projects which will not be located in a "sensitive area", but may have a certain limited impacts.)

The projects are likely to have less adverse impacts than those of Category A. An IEIA will be needed and its report shall be submitted to the MOE for review, comments and approval. If results of the IEIA reflect some potential and critical environmental issues, an EIA would be required based on judgment of the MOE.

c. Category C projects

(The projects which will not be located in a "sensitive area", and their potential environmental impacts are negligible.)

The projects are likely to have minimal or no adverse impacts. For such cases, no IEIA will be required. However, environmental screening will be needed to ensure that potential environmental impacts will be minimum or negligible. The results of the environmental screening shall be submitted to MOE for its review and comments.

If MOE deems need of IEIA, the project proponents shall carry out an IEIA and submit it to MOE for review, comments and approval.

Table AP-D.1.1 of **Appendix-D** shows the "Illustrative List of Sensitive Sectors, Characteristics, and Areas". A project will be categorized as Category A if it is relevant to the list.

In principle, a project classified as Category I or Category A will need EIA. In that case, an IEIA shall be conducted during pre-feasibility study stage, and a full scale EIA shall be carried out during its feasibility study stage.

(iii) Carrying out Scoping for Conducting an IEIA or EIA

"Scoping" means deciding the scope of work (study items to be covered) and the extent of details of IEIA or EIA.

a. Scoping for conducting an IEIA or EIA shall be carried out based on the results of the environmental screening and project categorization.

b. Table AP-D.1.3 of **Appendix-D** shows the generic and basic study items to be covered by EIA. All the scope of work items listed are not applicable to all the cases of IEIA. The column of "Remarks" is provided for some items that may not be applicable to a specific project. Details depend on each project. For example, the item of "Environmental Management Plan" may not be required to such projects as rural electrification by renewable energy in the off-grid area.

(iv) Conduct an IEIA and/or EIA as Required Based on the Results of the above.

(3) Information/Data Collection and Field Surveys Required for Environmental Screening, IEIA and EIA

a. For conducting an environmental screening, collect and use existing data and carry out initial field surveys.

b. For conducting an IEIA, collect and use existing data and carry out field surveys.

c. For conducting an EIA, collect and use both primary and secondary data (new data). Also carry out field surveys.

(4) At pre-feasibility study stage of proposed projects, project owner must conduct an IEIA and submit its report to the MOE and concerned authorities for examination. If MOE judges that an EIA is required, the project owner must conduct an EIA during the feasibility study stage and submit its report to the MOE and concerned authorities for examination, comments and approval.

(5) Final decision will be made by the MOE.

Figure 2.1.6 shows the Process of Conducting an IEIA and/or EIA for **Case III** projects.

(6) Factors to be considered in IEIA and/or EIA of RE projects by renewable energy

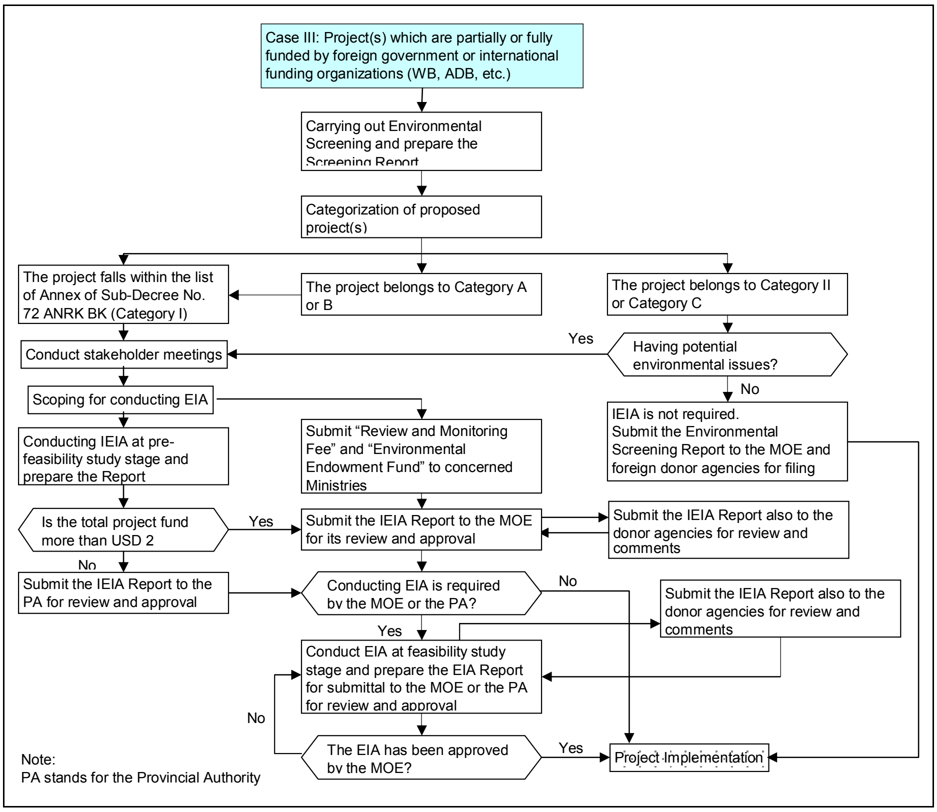
Key factors to be considered in connection with the environmental regulatory requirements of RGC are shown below:

a. If a project site will be located in a Protected Area, conducting an IEIA will be required. For details, refer to Figure 2.1.4 "The Process of Conducting an IEIA and/or EIA for **Case I** Projects".

b. If a bundle of small-scale RE projects by using renewable energy will be applied to be the CDM projects, "a bundled SSC Project activity" concept and procedures can be applicable. For details, refer to Section (2)-3 "The Guide for **Case II** Projects" of the above.

c. Project proponents shall consult in advance with concerned personnel of the MOE in charge for carrying out environmental consideration activities.

d. Holding stakeholders meetings is essential and required at various stages for reflecting the opinions, needs and comments of concerned parties, especially those of ethnic minorities, indigenous people if they inhabit in the project site area.



Source: JICA Study Team

Figure 2.1.6 The Process of Conducting an IEIA and/or EIA for Case III Projects

2.2 ECONOMIC AND FINANCIAL ANALYSIS

2.2.1 Cost comparative analysis

(1) Comparison of Solar BCS and Diesel BCS

Table 2.2.1 shows the estimated costs of diesel BCS and solar BCS. A diesel BCS of 3 kVA can provide through battery 2.52 kWh per household per month. The total electricity supply would amount to 61.2 GWh per annum if BCS is to supply electrify to all the households having no grid connection. The present worth of such energy consumed through batteries would amount to 979 GWh in total of the off-grid areas. Solar BCS will cost about 118% of the diesel BCS cost.

A subsidy in an order of $205 million would be required to invite REEs for implementing a hypothetical policy to convert all the existing diesel BCS to solar BCS as well as to newly provide solar BCS in non-electrified (no BCS) villages countrywide. This incentive corresponds to 39% of the capital costs of solar BCS. This will reduce the capital investment of REE from $520 million to $315 million.

However, the end users of solar BCS will still require costs for home battery at $332 million nationwide in present worth even after the subsidy above to REE. In addition, the end users have to pay battery charging fee to REE.

Table 2.2.1 Cost comparative analysis (Diesel BCS and Solar BCS)

(Unit: million $)

Items	Diesel BCS	Solar BCS
1. Total capital cost	84	520
2. Annual O&M cost	39	16
NPV of BCS cost (2005 to 2030)*DR=4%	771	968
4. NPV of battery cost	332	332
5. NPV of total costs	1,103	1,300
6. NPV of electricity consumed through batteries/grid	979 GWh	979 GWh
7. Unit cost of electricity at the consumer end	$1.13/kWh	$1.33/kWh
8. Disparity level to a tariff at Riel 350/kWh in Phnom Penh before subsidy	1,288%	1,518%

(Source: JICA Study Team)

(2) Comparison of Biomass Gasification Power Generation mini-grid and Diesel Generation mini-grid

We analyze estimated costs of diesel generation (DG) mini-grid, biomass gasification power generation (BGPG) mini-grid and micro hydro power mini-grid under following conditions (Table 2.2.2):

Table 2.2.2 Conditions of Cost Comparative Analysis (Mini-grids by DG, BGPG and MHP)

	Generator Capacity (Continuous)	Length of LV & MV lines	Unit consum ption	House Holds (h.h.)	Operation hour per day	Monthly sales per house Holds
DG mini-grid case	28kW 25% subsidy 25% Equity 50% Loan: 10yrs, interest rate 10%	3.0km/1.1km 25% subsidy 25% Equity 50% Loan: 20yrs, interest rate 7%	100W	215	3.33hr	10kWh/month
BGPG mini-grid case	28kW 25% subsidy 15% Equity 60% Loan: 10yrs, interest rate 7%	3.0km/1.1km 25% subsidy 15% Equity 60% Loan: 20yrs, interest rate 7%	100W	215	3.33hr	10kWh/month
Micro Hydro mini-grid case	28kW 25% subsidy 15% Equity 60% Loan: 20yrs, interest rate 7%	3.0km/7.3km 25% subsidy 15% Equity 60% Loan: 20yrs, interest rate 7%	100W	215	3.33hr	10kWh/month

Note: Above funding sources based on REE owned by private
(Source : JICA Study Team)

Table 2.2.3 shows the estimated costs of diesel generation (DG) mini-grid, biomass gasification power generation (BGPG) mini-grid and micro hydro mini-grid. Detailed calculations for each case is presented in Appendix E.

Assuming the demand is 100 W per household and electricity consumption is 10 kWh/month, the estimated cost of DG mini-grid is 49.6 ¢ /kWh. The estimated cost of BGPG mini-grid is 44.4 ¢ /kWh. BGPG mini-grid will cost about 89% of the DG mini-grid cost. On the other hand, the estimated cost of micro hydro mini-grid is 72.5 ¢ /kWh, which is about 146% of the DG mini-grid cost.

Table 2.2.3 Cost comparative analysis (Diesel mini-grid, Biomass Gasification Power Generation mini-grid and Micro Hydro Power mini-grid)

(Unit: $)

Items	Diesel mini-grid	Biomass Gasification Power Generation mini-grid	Micro Hydro Power mini-grid
1. Capital cost	49,904	74,054	166,514
1.1 Generator (28kW / 215 house holds)	10,500	31,500	84,000
1.2 LV&MV lines (LV 3.0km, MV 0.4km*)	20,925	20,925	48,825
1.3 Other costs	18,479	21,629	33,689
2. Annual Cost	12,968	11,598	18,940
2.1 Capital Cost	5,540	8,730	15,720
2.2 Fuel Cost	5,488	348	0
2.3 O&M Cost	1,940	2,520	3,220
3. Annual Energy Sold	26.1 MWh	26.1 MWh	26.1 MWh
4. kWh Cost at the consumer end	$0.496/kWh	$0.444/kWh	$0.725/kWh
5. kWh Cost a tariff at Riel 350/kWh in Phnom Penh	567%	507%	828%

*Micro Hydro: MV Lines 7.3km
(Source: JICA Study Team)

(3) Comparison of Annual Generation Costs of Alternative Power Sources

We analyze annual generation costs of alternative power sources under following conditions (Table 2.2.4):

Table 2.2.4 Conditions of Annual Generation Costs of Alternative Power Sources

Unit Cost Data Unit:US$

	Unit	Diesel	Micro hydro	Biomas	Grid extension
Capital (Total)	$/kW	3,267	9,454	4,555	3,590
Capital (generation costs/grid	$/kW	830	4,294	1,950	1,311
Capital (distribution costs)	$/kW	1,626	3,542	1,626	1,426
Capital (Connection costs)	$/kW	385	385	385	385
Indirect Cost (15%)	$/kW	426	1,233	594	468
Annual Cost of Capital	$/kW	330	816	499	287
Fuel	$/kWh	0.23	0	0.03	0
O & M (generator/grid)	%	5.0%	2.0%	3.7%	2.0%
O & M (distribution line/conn	%	2.0%	2.0%	2.0%	2.0%
O & M (generator/grid)		42	86	72	26
O & M (distribution line/connection)		40	79	40	36
Bulk purchase*	$/kWh	0	0	0	0.123

Note:Capital recovery factor (10%, 10-year repayment) = 0.163 Diesel

Capital recovery factor (7%, 10-year repayment) = 0.149 Biomas

Capital recovery factor (7%, 20-year repayment) = 0.094 Micro Hydro

Capital recovery factor (7%, 30-year repayment) = 0.080 Grid/distribution)

(Source: JICA Study Team)

Table 2.2.5 shows the estimated generation costs of alternative power sources.

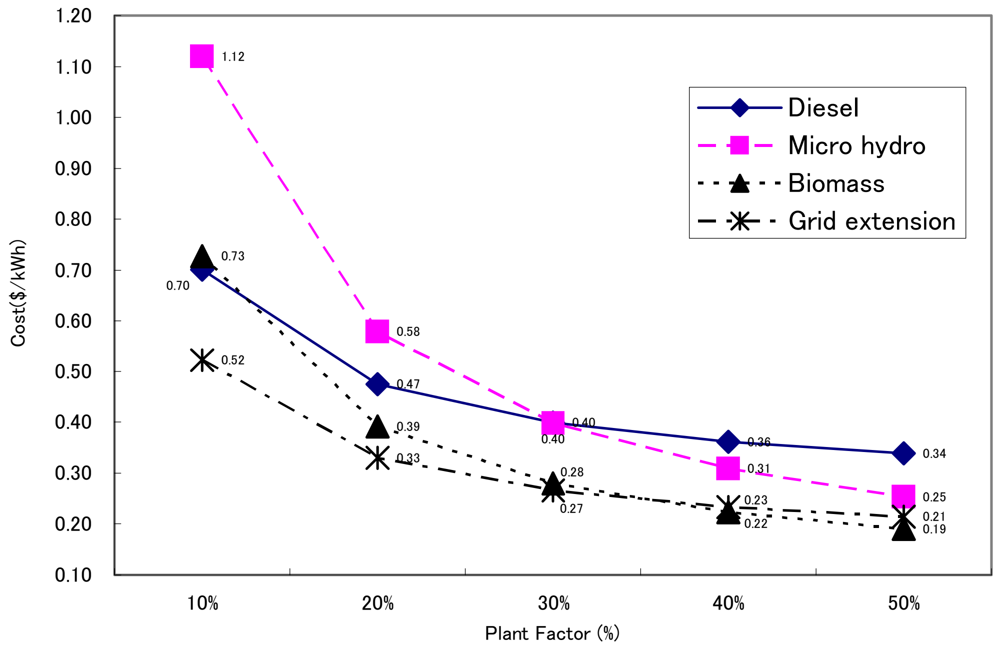
Figure 2.2.6 shows the estimated generation costs per kWh of alternative power sources.

Estimation shows that Grid extension will be lowest cost under less than 40% of plant factor conditions. If the plant factor is 30%, the second lowest is Biomass Gasification Power, and the third one is Micro Hydro Power. Diesel Power can be the second lowest, if the plant factor is below 10%.

Table 2.2.5 Comparison of Annual Generation Costs of Alternative Power Sources

	Plant factor	10%		20%		30%		40%		50%	
		(876 kWh)	Rank	(1,752 kWH)	Rank	(2,628 kWh)	Rank	(4,380 kWh)	Rank	(7,008 kWh)	Rank
Diesel	Capital	330		330		330		330		330	
	Fuel	201		403		604		806		1,007	
	O&M	82		98		114		131		147	
	Total	613	②	831	③	1,049	④	1,267	④	1,485	④
	$/kWh	0.700		0.474		0.399		0.362		0.339	
Micro hydro	Capital	816		816		816		816		816	
	Fuel	0		0		0		0		0	
	O&M	164		197		230		263		296	
	Total	981	④	1,014	④	1,047	③	1,080	③	1,112	③
	$/kWh	1.120		0.579		0.398		0.308		0.254	
Biomass	Capital	499		499		499		499		499	
	Fuel	26		53		79		105		131	
	O&M	112		135		157		180		202	
	Total	638	③	686	②	735	②	784	②	833	①
	$/kWh	0.728		0.392		0.280		0.224		0.190	
Grid extension	Capital	287		287		287		287		287	
	Fuel	0		0		0		0		0	
	O&M	62		75		87		100		112	
	Bulk pur.	108		215		323		430		538	
	Total	457	①	577	①	697	①	817	①	938	②
	$/kWh	0.522		0.330		0.265		0.233		0.214	

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 2.2.6 Generation Costs of Alternative Power Sources

2.3 IMPLEMENTING ORGANIZATIONS AND RESPONSIBILITY

2.3.1 Stakeholders for Implementation and Their Division of Roles

As discussed in Chap. 1.6.4 of Part 2, main stakeholders involved in the rural electrification program and their roles are summarized below:

- EdC: responsible for implementation of national grid-extension
- REE: responsible for implementation of off-grid supply system (private -owned)
- CEC: responsible for implementation of off-grid supply system (Community-ownership or Consumer Co-operatives)
- REU: responsible for implementation of off-grid supply system (local gov't-owned)
- NGO: responsible for training and supporting REEs and CECs
- MIME: responsible for granting concessions to the investors
- EAC: responsible for licensing and regulation
- MRD: responsible for approving sub-projects using SEILA program

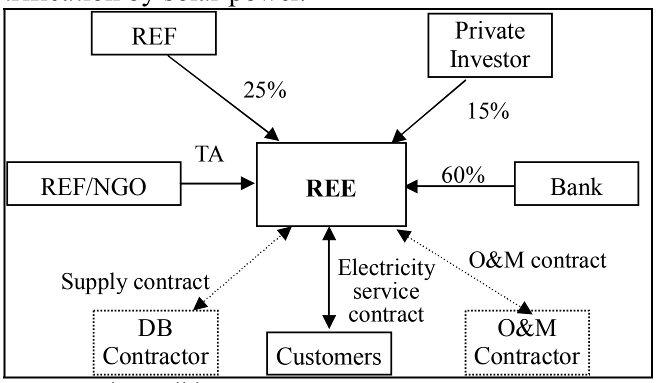
The implementation responsibilities of the stakeholders concerned are organized in Table 2.3.1. The table includes exceptional cases of MIME-owned national solar system distribution companies and local government-owned rural electricity utilities. The discussion from now on will be concentrated to standard cases of EdC, REE and CEC-owned business models.

Table 2.3.1 Implementation Responsibility of Stakeholders

Business Model	Ownership	Operation	Training and Facilitation	Approval	Licensing and Regulation
EdC	EdC	EdC or REE	-	MIME/REF	EAC
REE	REE	REE	EdC or NGO	MIME/REF	EAC
CEC	CEC	CEC	NGO	MIME and Local Government	EAC
Solar BCS/PV system	MIME	CEC	MIME or NGO	-	-
REU	Local Gov't	Own force or REE	EdC	MIME	EAC

Source: JICA Study Team

Typical implementation organizations of the three main player of off-grid models (REE, CEC and REC) are shown below. Here REC means Renewable Energy Center which is owned by MIME for remote and social electrification by solar power.



DB: Design Build

Figure 2.3.1a Private-owned REE Model

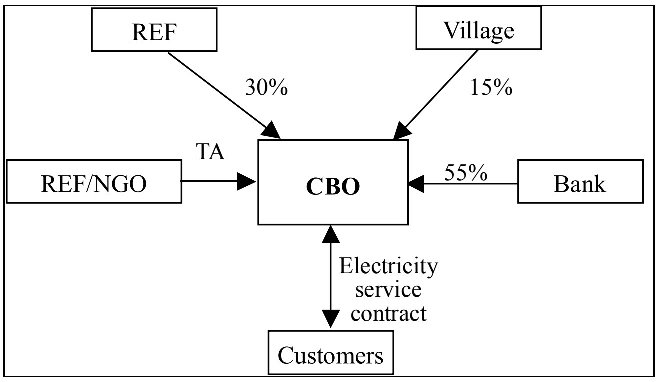


Figure 2.3.1b Community-owned REE Model (CEC Model)

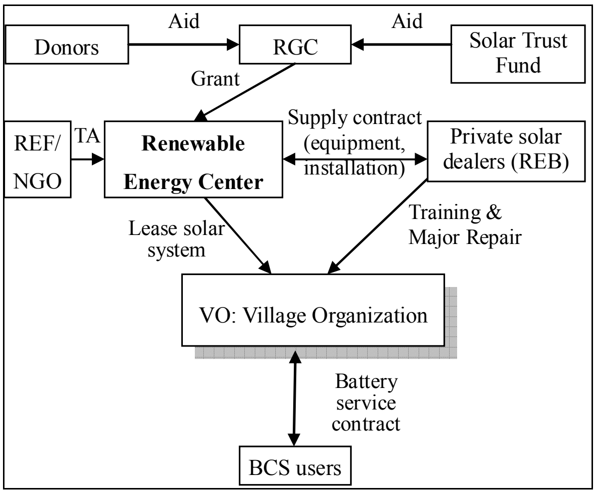


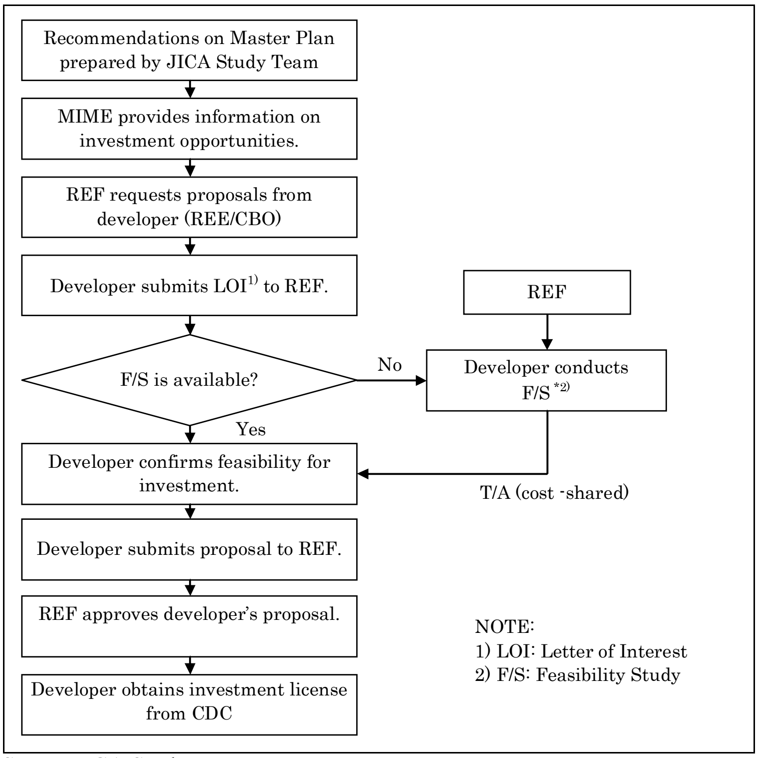
Figure 2.3.1c Renewable Energy Center (REC) Model

The demarcation between REE and CEC is discussed in Chap. 2.3.3 below.

The private developers (REE, CEC and NGO) can invest in the rural electrification project pursuant to the MIME/REF program procedure under the following steps (The principle of off-gird rural electrification is the bottom-up approach. The procedure below supposes the implementation of a model project in the early stages of the rural electrification program. For the full-scale implementation of the program proposed in the Master Plan, a community initiated approach will be adopted, where REF/CFR will evaluate the submitted electrification plan and request for financial assistance by the CEC/REE, and assist those that have satisfied the standard).

1) MIME selects and announces priority projects/areas (in prior consultation with communities concerned).
2) REF requests proposals from private developer (REE/CEC).
3) Developer submits letter of interest to REF.
4) Developer conducts feasibility study with support of REF.
5) Developer confirms feasibility for investment.
6) Developer submits proposal to REF.
7) REF approves developer's proposal in consultation with EAC.
8) Developer obtains investment approval for CDC and business license from EAC.

The above investment process is shown below:



Source JICA Study Team

Figure 2.3.2 Flowchart of Investment Process by MIME/REF Application

2.3.2 Demarcation between EdC and REE

Division of roles between EdC and REE is set out as follows:

- EdC is responsible for: (i) HV extension and MV extension to priority supply areas of PAGE; and (ii) MV extension to high demand areas within PAGE.
- REE is responsible for: (i) upgrading of existing REE grids to MV system to be connected to the national grids; and (ii) extension of existing mini grids to connect new customers.

There are observed some areas within PAGE where REEs face competition from EdC and crowding out and/or taking-over of existing REEs by EdC with progress of the latter system expansion are taking place. Under the RGC policy of prioritizing REEs, EdC should announce firmly their plans, and REEs should acquire licensing from EAC. Grid extension by EdC does not obstruct business conducted by REEs, but aims to supply cheap electricity to the REEs. Clear boundaries should be drawn between the operational areas of EdC and REEs through issuance of licenses by EAC.

With expansion of EdC grid areas the REE grid areas are also expected to expand since most REEs are willing to be in peri-urban and rural town areas and close enough to EdC's operations, so that the interface between activities of EdC and REEs should be coordinated and adjusted properly.

2.3.3 Demarcation between REE and CEC

REEs are private businesses which are driven to do business by private interests. Things which are vital in attracting REEs' interests are: (i) household density, (ii) strong local economy (high demand and affordability to pay), and (iii) availability of cheap and stable energy sources. Therefore the demarcation between REEs and CECs is generally made as follows:

- REE mini grid areas will cover the areas attracting the private interests and the medium/high income areas with the number of customers above a certain threshold, say 200 or more.
- CEC mini grid areas will be relatively lower income areas with little REEs' interests, yet where possible consumer cooperatives or committee for electrification can be established. These conditions include:
    - i) willing to provide free labors to help with installation of plants and equipment and erection of lines as well as own construction of access roads, etc.
    - ii) able to manage operation, collect revenues from sales and organize maintenance of the system

Preliminary results of socio-economic surveys revealed the following areas are seen as likely for those community-ownership options:

- South-western area including Pusat, Koh Kong and parts of Kampot and Battambang provinces
- Northern area including parts of Siem Reap and Preah Vihar provinces
- Eastern area including Ratana Kiri, Stung Treng and Modul Kiri province

For stand-alone systems (solar BCS/PV system), there is an observation that making distinction between REE and CEC is not practical. Pure private business-minded REEs entering off-grid remote villages are very few. Therefore, solar BCS/PV system can be operated by public offices such as health post, commune center, school and so on especially if they are financed by external grants. Yet, such operation also needs to be monitored by local authorities together with technical backstop entities, possibly by NGOs.

Meanwhile, there is few support for CEC ownership due to the fact that unsatisfactory experience of community based activities in Cambodia. Most of RGC officials and some other donors, therefore, recommend the electricity service should be provided by professional business entities like REEs.

The roles and functions of the entities (MIME, REF, EAC, NGO, etc) other than EdC, REE and CEC are described in Chap. 2.2 of Part 1.

2.4 IMPACTS ON VILLAGE DEVELOPMENT

Community-owned electrification projects require considerable analysis and various levels of public consultation and community participation during project planning and preparation stages. Communities must be center of project preparation to ensure the projects meet community development priorities and are integrated into ongoing community development activities.

The electrification schemes by renewable energy may contribute directly or indirectly to achieve Millennium Development Goal (MDG). Table2.4.1 shows a list of indicators to be considered for monitoring and evaluation process for rural electrification project by renewable energy.

Table2.4.1 Indicative Electrification Impact Indicators for Households

MDGs	Indicative indicators to measure to impacts
Eradicate poverty and hunger	Number of households benefiting form projects according to income Number of poor households with increase in productive use
Achieve universal primary education	Number of extra hours children spend on education at home Number of quality of lighting and energy access for schools Number of informal literacy classes in evening.
Reduce child mortality / Improve maternal health / Combat HIV and malaria and other diseases	Lighting in rural clinics Reduction of smoke /use of clean fuels Decrease in workload for women directly or indirectly Improvement of sanitation after electricity as communication tools introduced
Ensure environmental sustainability	Saving of fuel wood Usage of local renewable resources with less negative environmental impact Increase of access to clean drinking / pumped water

Source: Monitoring and Evaluation of the Impact of Renewable Energy Programmes: A Toolkit for Applying Participatory Approaches, Renewable Energy & Efficiency Partnership, IT Power, 2005 (modified by JICA Study Team)

Yet it is well known that rural electrification will not induce industrial growth automatically. When other prerequisites such as technical and financial support schemes were absent, demand for electricity for productive uses hardly grow. In order to maximize the impact of electrification, linkage among the stakeholders; local government authorities including other departments and DIME, NGOs will be needed. During the commune council and district integration workshops regularly scheduled under the decentralization program, electrification project have to be included together with other infrastructure program.

3. SELECTION OF IMPLEMENTING SCHEMES

3.1 ELECTRIFICATION SCHEMES BY VILLAGE

3.1.1 Village Data Available for MP2005

The total number of villages in Cambodia amounts to 13,910. (According to the survey result of the JICA Study Team, the number is increased to 13,914 with 4 new villages.)[4] Electrification data (electrification level by REE and diffusion level of battery) in NIS database 1998[5] is used for energy sources selection, because of limited availability of data on village electrification status. However, during the period of seven years from 1998 to 2005, battery lighting was rapidly diffused allover Cambodia. Therefore, data on the diffusion level of television in Seila database 2003 and results of six province survey on rural electrification (undertaken by the Study Team in January & February 2005) were also referred to.

3.1.2 Off-Grid Area

Before selection of energy source for each village, the off-grid area needs to be defined. The on-grid area as of 2008 and off-grid area 2008 are shown in Figure 2.2.1 of Part 2. The villages in the off-grid area is identified as 11,635 in total.

3.1.3 Selection of Energy Sources

In the Master Plan 2005, source of energy for each non-electrified village was selected based on the data above and flowchart shown in Figure 3.1.1.

Villages where diffusion level of battery is assumed to be below 50% are grouped into solar BCS (RE Stage 1, 10 W per household as standard, and 40 W per household with TV as an option). Villages, where diffusion level of battery is expected to be higher than 50%, would have high demand of electrification and ability to pay for the standard tariff of mini-grids ($0.40-0.50/kWh x 7-10 kWh per month per household = $2.8-5.0 per month per household). Such villages are grouped into decentralized mini-grids (RE Stage 2; 100 W per household as a nationwide average).

Decentralized mini-grids can further be sub-grouped into micro hydro (including hybrid systems), biomass gasification power, and diesel power. These electrification plans are summarized by region and by energy source in Table 3.1.1 and is shown by type in Figure 3.1.2. Installed capacity and estimated implementation costs are summarized also in Table 3.1.2.

---

4 The SEILA program of the Royal Government of Cambodia (2003), The Seila Program, which was launched in 1996, is an aid mobilization and coordination framework to support the country's decentralization and "deconcentration" reforms for rural area. Seila means "foundation stone" in Khmer Sanskrit.

5 NIS 1998, National Institute of Statistics (NIS), Ministry of Planning, 1998

Table 3.1.1 List of Energy Source and Number of Villages and Households, MP2005

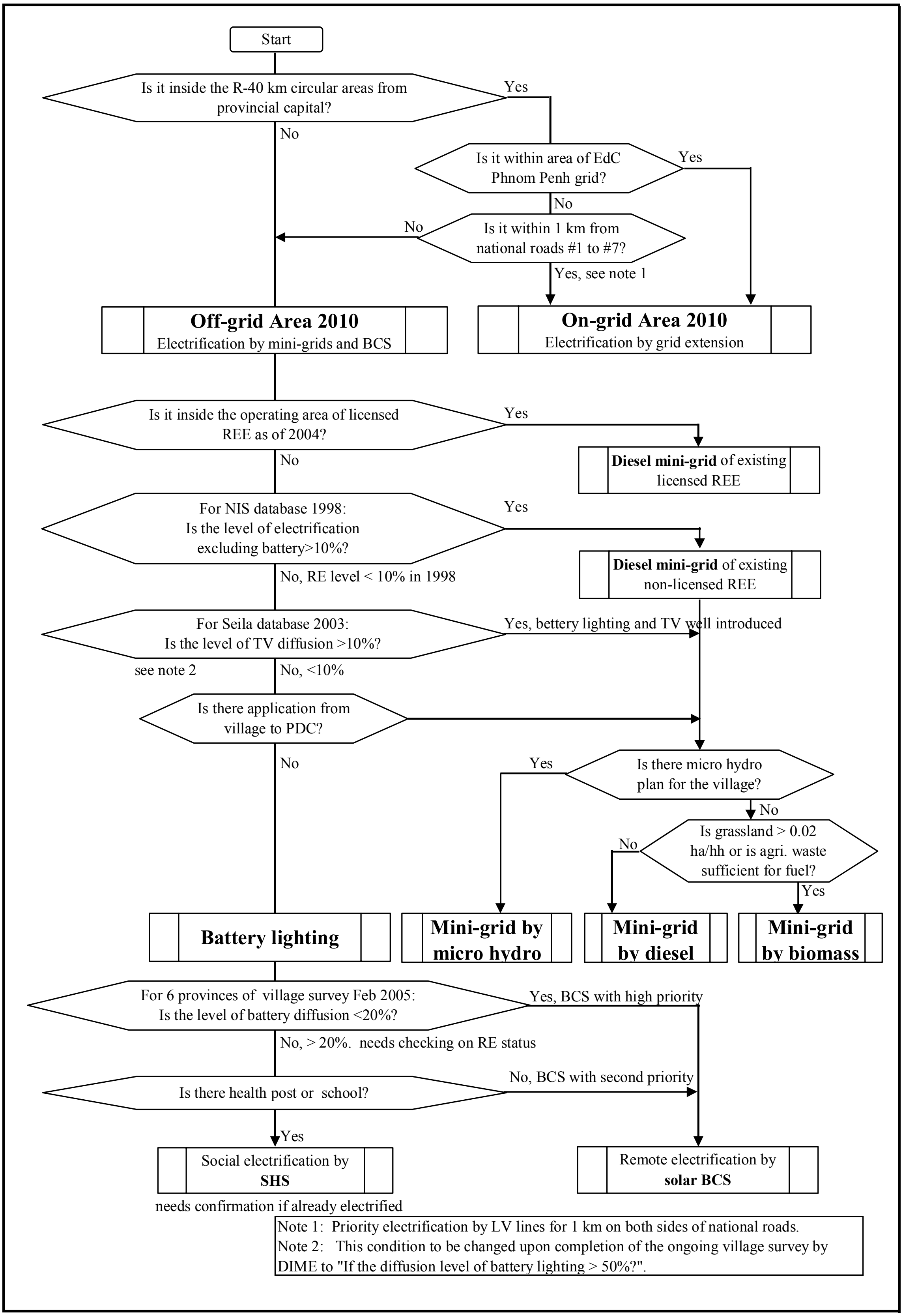
Name of Representative Regions	Energy Sources	Number of Villages	Number of Households
Electrified area	EdC Grid	1,405	313,387
	Isolated diesel mini-grids by REE Isolated mini diesel grid by REE with imported electricity	526	153,350
	Isolated mini diesel grid by non-registered REE	657	156,786
	The private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

Note: The list of the Electrification Plan by village is available in a computer file. The total number of villages is 13,194, because the new four villages are added to the number shown in the Seila database 2003.
Source: JICA Study Team

Table 3.1.2 Summary of the Installed Capacity and Construction Costs in the Rural Electrification Plan

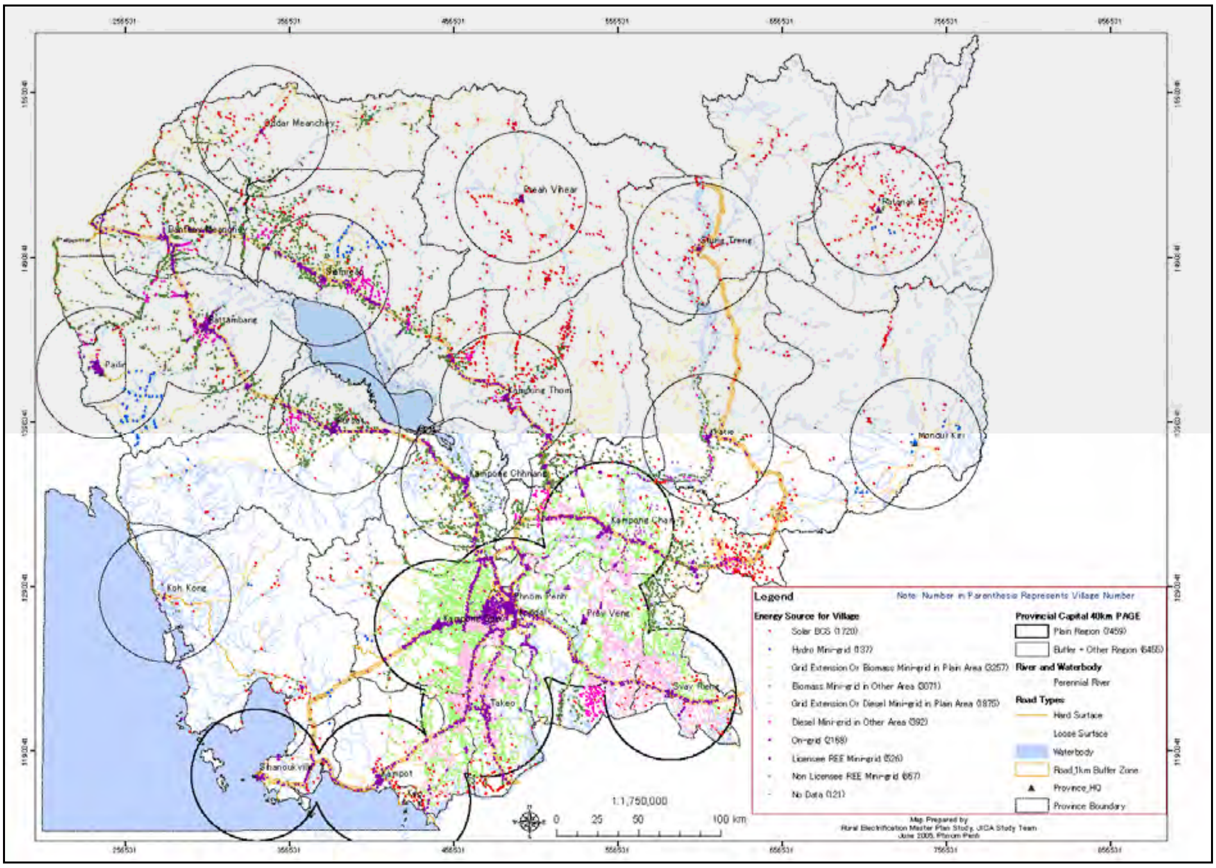
Type of Electrification	No. of Candidate Villages	No. of h.h. to be electrified by year 2020	Total Cost	Total Cost per h.h.	Fund Source of Capital Costs		
			($1,000)	($/h.h.)	Subsidy	Equity	Loan
Electrified as of 2005	2,062	(350,345)	-	-	-	-	-
Newly Electrified by Grid	6,411	**600,000**	**280,140**	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



Source: JICA Study Team

Figure 3.1.1 Flowchart for Preparing Electrification Plan of All Villages in Cambodia, MP2005



Source: JICA Study Team

Figure 3.1.2 Energy Source by Village, MP2005

3.1.4 Preparation of Electrification Plan for Each Village

Electrification plan was prepared for each village or scheme by energy source selected above.

Of the 13,914 villages, energy source of each village was identified in accordance with the flowchart shown in Figure 3.1.1. The potential energy sources are classified into the following six:

1) National grid or existing mini-grids;
2) New mini-grids by diesel;
3) New mini-grids by micro hydro;
4) New mini-grids by biomass gasification power;
5) Solar BCS and PV system for public facilities.

In addition to the above, there are the following energy sources:

1) Private diesel BCS;
2) Self diesel generator set;
3) Self pico hydro;
4) Private SHS;
5) Receiving supply from small private generators nearby.

However, these cannot be identified by the village data available and are, therefore, not specifically reflected to the energy source selection above.

After screening of all the villages by source of energy into the five energy groups above, installed capacity, required lengths of MV and LV distribution lines are obtained and construction costs estimated. Of the villages identified as candidates for mini-grids, those that have no hydro potential and no land available for growing fuel wood for biomass power (land of 0.02 ha per household required at the minimum) are grouped into diesel mini-grids.

In the "Plain Area" situated to the south of Phnom Penh (the provinces in the Plain Region plus Kampot, Kep and Sihanoukville, or the area encircled by thick arcs in Figure 3.1.2), there are many candidate villages for biomass or diesel mini-grids. This is mainly due to a reason that a grid extension plan in the Plain Area has not been prepared and was simply assumed in Figure 3.1.2 as only the area 1 km wide on both sides of the national roads. Actually, grid electrification of many of these villages would be implemented in the near future. Since the Plain Area has the highest priority for grid extension, these villages inside the Plain Area are treated in this Master Plan 2005 as "candidate villages for either grid extension or biomass mini-grids". People in these villages in particular are required to contact, before planning electrification of their own villages, EdC for the latest plan of grid extension in the Plain Area.

As for the villages surveyed by the experts of the JICA Study Team and MIME counterparts, mini-grids are planned by integrating multiple villages depending on the relative distance of villages in the region. Solar BCS is planned with a principle of one BCS for one candidate village. (If a village scale is greater than 200 households or if one village is geographically separated into two groups or more, it is desirable for the convenience of BCS users to install 2 or more BCS. Such guideline for planning of solar BCS is proposed to be included and compiled as a visual guide for use by REE and villagers, which can be prepared on the basis of Manual for Preparation of Electrification Plan, Volume 3 Part 2.)

The sources of energy selected for each village are shown by color in Figure 3.1.2. Table 3.1.3 presents a summary of number of villages screened with GIS into energy groups and number of schemes prepared by the respective experts of the JICA Study Team and counterpart team based on the joint village survey. Through the field assignments in December 2004, January 2005, and May-June 2005, the teams jointly made map study, hearing survey, and reconnaissance of prospective sites.

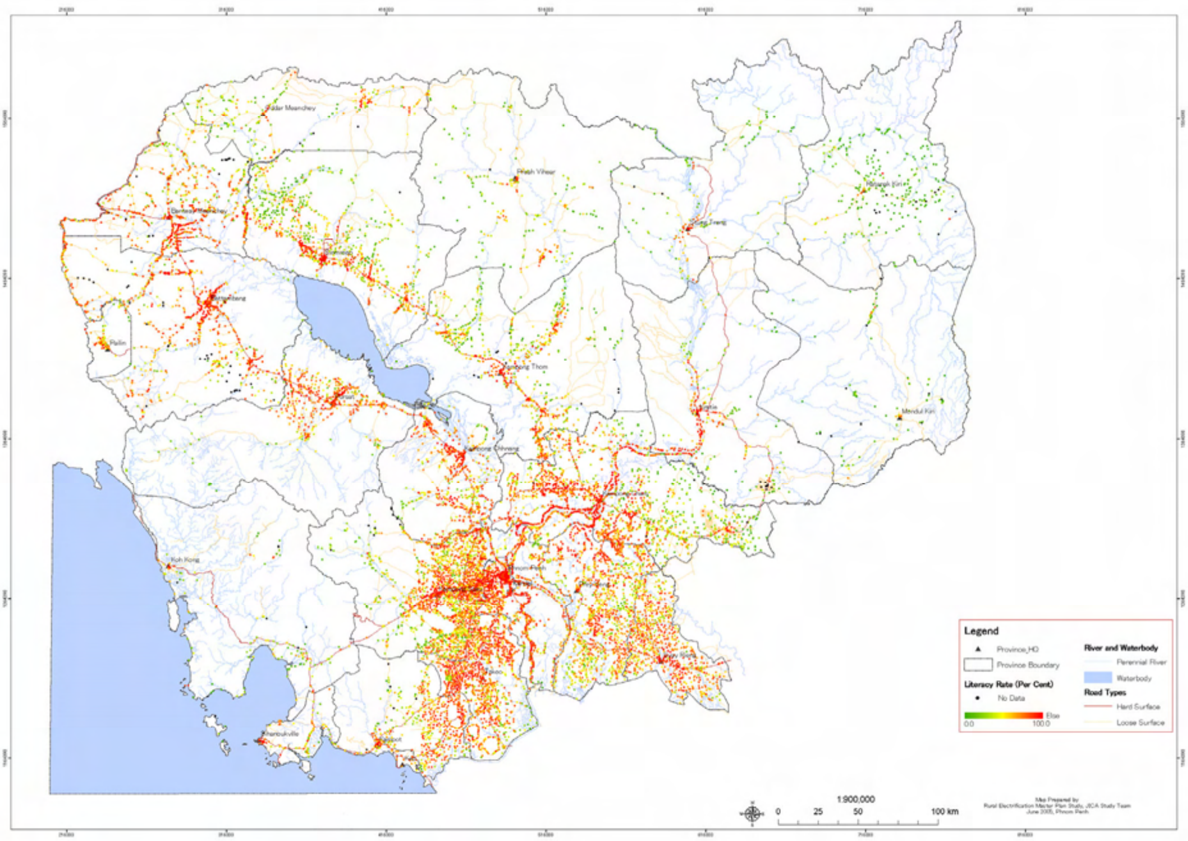
Table 3.1.3 Number of RE Schemes Identified and Inspected

No.	Type of Energy	Nos. of Villages Screened with GIS	Nos. of Schemes		
			Map Study	Potentials Matched with Villages	Schemes Inspected
1	Hybrid of MH & BG	137 vil. 18 schemes	-	8	5
2	Micro hydro		145	36	23
3	Biomass power	6,328	13 (48 vil.)	13	11
4	Diesel power	2,267	-	-	-
5	Solar power	1,720	21	-	21
6	Grid extension	753	-		-
7	Villages w/o data	121	-		-
Total		11,326	179	57	**60**

Source: JICA Study Team

The micro hydro team identified 145 schemes in the off-grid area. Of these, 44 schemes were formulated integrating villages nearby. Eight of the 44 need back up capacity in the dry season and are treated as hybrid schemes of micro hydro and biomass gasification power. 28 micro hydro sites were inspected on site, head and discharge measured. The biomass team identified 13 schemes as promising in view of fuel supply, commune activity, and/or daytime demand. Of these, 11 were inspected on site to examine the village conditions. The solar team visited 21 remote villages. All of these are candidates for either solar BCS or PV system for public facilities. In total, 60 prospective schemes were formulated and surveyed by respective teams.

A map of the level of literacy is developed based on the Seila database 2003 and is given in Figure 3.1.3. It is notable that the villages having literacy level below 50% are mostly those candidate villages for solar BCS. This shows solar BCS would contribute to reducing poverty. It may be regarded as a *social electrification program* for helping the poor.



Source: JICA Study Team

Figure 3.1.3 Level of Literacy

3.2 GIS DATABASE

3.2.1 Introduction

Information is one of the key factors for formulation and successful implementation of rural electrification projects. Such information comes in various types regarding, for example, its detail, parameters measured, digital or analogue, spatial and non-spatial, and so forth. Gathering all the available information and putting them together in organized manner results into a database. Thus, database is a shared collection of logically related data, designed to meet the information needs of multiple users in an organization. The data can be gathered or collected from various sources, which in many cases from governmental and non-governmental organizations. Source of data is an important factor for its utility because it keeps little value if it is not authentic.

3.2.2 GIS and GIS Database

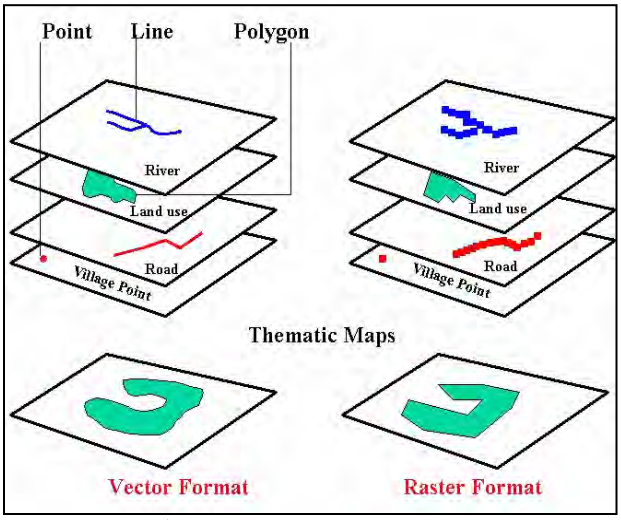
A collection of computer hardware, software, geographic and other related data, and personally designed and organized to efficiently capture, store, update, manipulate, analyze, and display all the forms of geographically referenced information creates a system, which is called as Geographic Information System or simply GIS (abbreviated form). Here we can see GIS has many components where database is one of them.

GIS database can be called as specialized form of database for storing and manipulating geographic information. It has two parts namely Spatial and Attribute data. Spatial deals with the location on earth while attribute tells us characteristics of the item in question. For example, "X" and "Y" coordinate can determine the location of a building on map as a point with ID and its properties (number of room, floor area, etc.) can be added as attribute data.

3.2.3 Types of GIS Data

There are basically two main methods of storing data in GIS, namely vector and raster. Depending upon the nature of map features, point, line and polygon are used to define them. Both vector and raster format can be used to store these features, but with different level of accuracy. Vector, which stores map features using vertices, is more accurate and mostly used for legal boundaries (for example land boundaries in urban area, national boundaries, etc.) and network analysis. On the other hand raster, which store map feature using generalized regular shaped grid, is less accurate than that of vector and mostly preferred for digital terrain model, remote sensing, natural resources (Solar Irradiance Map for example), statistical analysis, simulation and modeling etc.

Geographic data comes in various forms, for example village points, river network line, country land use features and so on. For better data query and analysis, GIS database has been designed to store geographical data in thematic form in most of the cases. A thematic geographic data is specific to single item, for example a river network map of the country, village location map, electricity distribution line, etc. Diagrammatic illustration in Figure 3.2.1 shows different data types used in GIS.



Source: JICA Study Team

Figure 3.2.1 GIS Data Types

3.2.4 Standardization of Data Format for GIS Database

It is well known fact that the standard data format must be followed while creating the common database. This is especially very important when there are several users on the same database. Furthermore, we have diverse type of data (socioeconomic, geographic, scientific observations, etc.) from various sources; those obtained from different organizations, members of the Study Team through field reconnaissance/survey and interview/questionnaire. Considering these facts and to keep homogeneity, we have formulated standard data format while inputting/coding the data regarding items listed below:

1) ID (identification number) of the Data: Each item of either observed or secondary source data has been given unique ID. Consistency has been maintained in the ID, in the case where the same item observed next time.

2) Name of the item: Similarly, once name of the item has been provided, consistency has been maintained onward.

3) Coordinate (location) of the item: To locate and/or create map, the item should be provided with X and Y coordinates. For example, during field survey it is desirable to get portable GPS reading for each observed points/line/polygon. Single coordinate defines the point while there are start and end point coordinates along with several vertices in between for line. Finally, polygon is defined by the same start and end coordinates along with several vertices in between.

4) Map projection: To overlay different maps, we need to project them in the same coordinate system. In this MP study project, the following map projection has been selected because currently this system is widely/commonly used in Cambodia:

   <u>Map projection</u>

   i) Projection type: UTM (Universal Transverse Mercator)

   ii) Zone: 48 N

   iii) Datum: Indian 1960 (ING_B)

   iv) Spheroid: Everest

   v) False easting: 500000.0000

   vi) False northing: 0.00000000

vii) Central meridian: 105.0000

viii) Scale factor: 0.999000

ix) Latitude of origin: 0.00000

As we know, there are several types of map projection system and it is possible to re-project the map to create common database with the same projection system.

Political boundary map code of Cambodia: Numerical digital code, comprising 8 numbers (for example 01010101), has been created and widely followed in Cambodia. The sequence of code is as follows:

i) First two digits represent Province: 01

ii) Second two digits represent District: 01

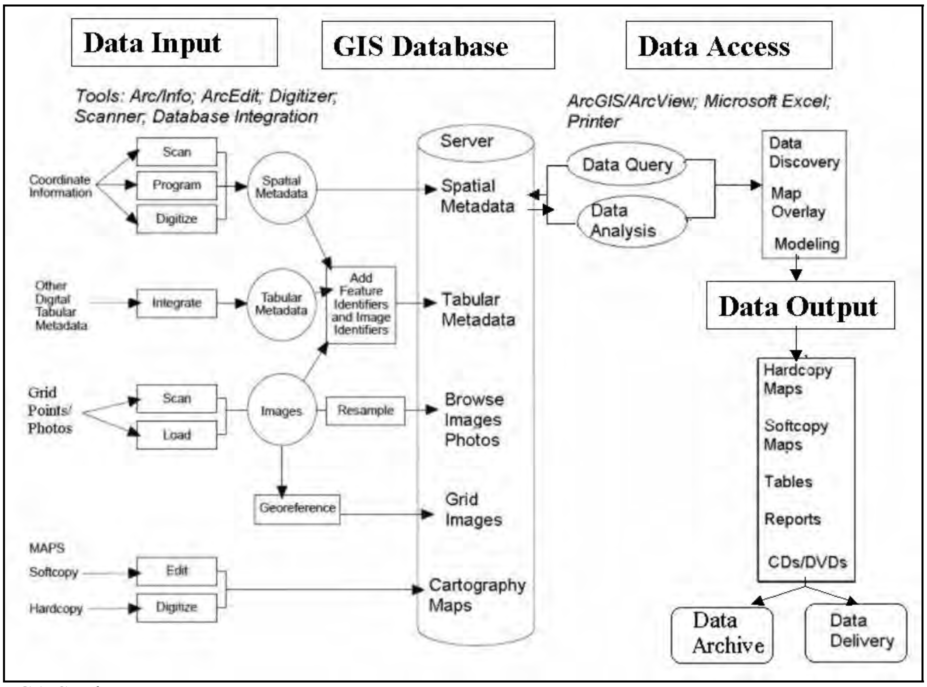
iii) Third two digits represent Commune: 01

iv) Forth two digits represent Village: 01

Recently, NIS (National Institute of Statistics), Ministry of Planning has created common nomenclature for Province, District and Commune and can be found at http://www.nis.gov.kh/. It has been decided to follow similar nomenclature of NIS.

3.2.5 Data Sources for GIS Database

Data input in the GIS needs both time and money. In many cases GIS database is usually created from both primary and secondary sources. Considering the nature of this project and availability of the GIS digital data form prior projects, secondary source of data makes the bulk portion in this database. Some essential, but unavailable, data has been created for this project. Furthermore, data also came from the filed observation and survey of various kinds. Schematic diagram (Figure 3.2.2) shows the procedure of GIS database creation and its utilization.



Source: JICA Study Team

Figure 3.2.2 Schematic Flow for GIS Database Input/Output

(1) Collection of Existing Data

Main source of data for this project comes from the existing data in the country, mainly with government ministries. Among them, the Ministry of Public Works and Transportation (MPWT) dataset is the main source. The MPWT dataset was recently prepared by PASCO, Japan under a JICA funded project. This dataset is comprehensive and covers wide variety of filed along with well prepared metadata. Two more important sources of data are SEILA and NIS, specifically for village level socioeconomic data. Besides, as mentioned earlier, contribution also came from different government and non-governmental organizations.

(2) Creating/Extracting New Data

New dataset has been created for some important information for this project. For example there is unavailability of the digital data about the command area of existing REE (Rural Electricity Enterprise). We have created REE command area and other related information about REE licensee digital data from the hardcopy information provided by the EAC (Electricity Authority of Cambodia) and stored in our GIS database. Similarly, some new data/maps have been extracted from the existing information by manipulating/combining/analyzing them.

Finally, as illustrated in flow of data input diagram (Figure 3.2.2), data from various sources had been inputted to the GIS database server. The project has a common server where every member has access. Table 3.2.1 gives the list of data that forms our GIS database till the date.

Table 3.2.1 List of Data Collected, Created and Compiled for GIS Database

No.	Data Folder	Description	# Coverage
1	BND	The boundary map	6
2	CAMInfo_CDR_NIS	XLS files attribute data extracted from CAMInfo customized NIS (National Institute of Statistic, MoP) CDR and Poverty map was created	1
3	CMAA_LandMine	Landmine data obtained from Cambodian Mine Action and Victim Assistance Authority (CMAA)	3
4	MoP_VillPoints	Village Point data obtained from MPWT. This folder also contains some processed data based on the attributes extracted from NIS data (1998 Census WinR+ Population Database).	10
5	NIS_Health_Coverage2004	Hospital location data extracted from CDR "Administrative and Health Facility Mapping 2004" prepared by NIS in collaboration with UNFPA and UNWFP.	4
6	Seila101204	Socioeconomic data and village location data from Seila	1
7	MPWT/JICA/PASCO datasets	Data created by JICA funded project conducted by PASCO Corp. in collaboration with MPWT. Out of several data/maps required one were extracted and stored	6
8	REE_Data	REE Licensee Command Area Data, created by JICA Study Team.	2
9	Protected_Area	Protected Area Map of Cambodia obtained from Dept. of Forest	1
10	Solar_Wind	Solar and Wind Potentiality map of Cambodia, Original point data was obtained from NASA homepage and the grid data was created by JICA Study Team	26
11	JST_Output	JICA Study Team (JST) has produced several maps by analyzing/manipulating the original data from other sources	Several
12	Village_Data	Village GIS Dataset created by using "Village Location" and "Socioeconomic Data" from SEILA	1

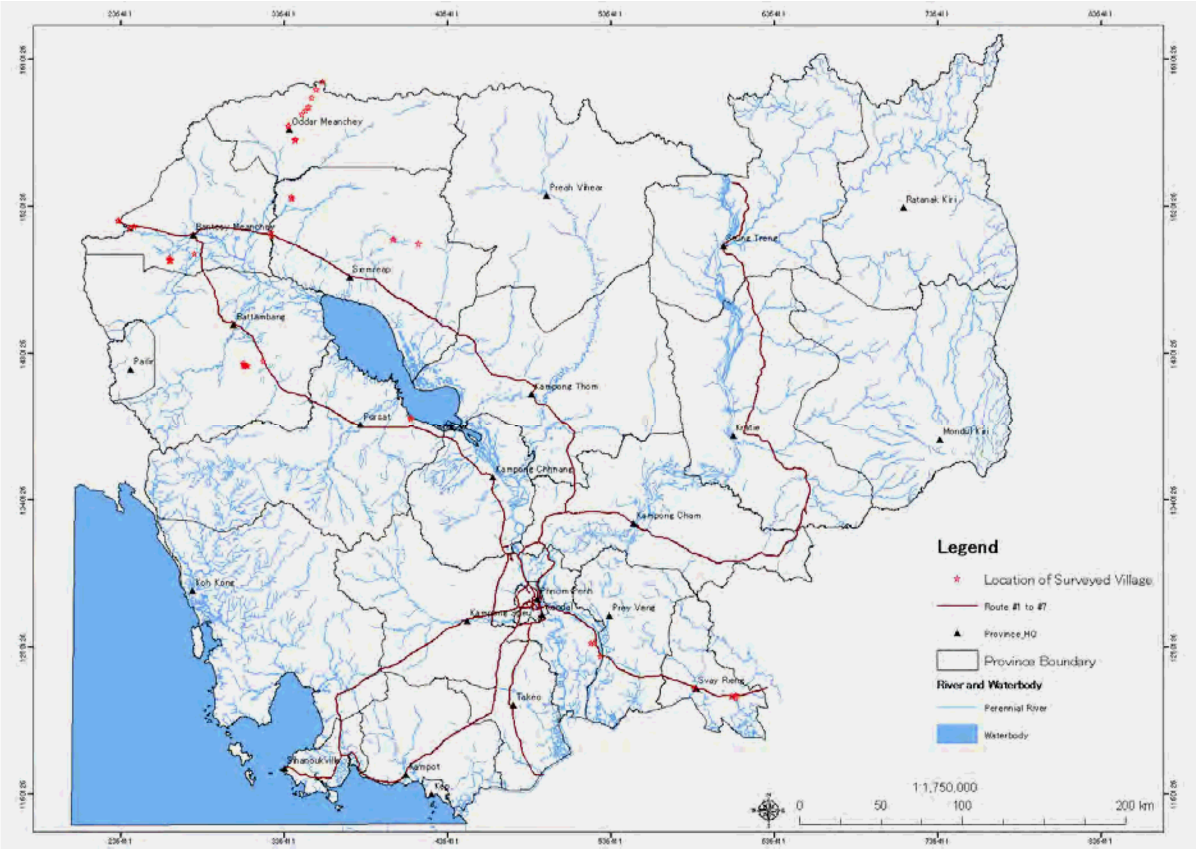
Source: JICA Study Team

At the moment, various field observation and survey are going on. After completion of these observation/survey, these data will be complied for GIS database wherever applicable and feasible.

3.2.6 Field Verification of Village Data

There is considerable amount of data ambiguity between Seila and NIS village dataset. Before using any data, if possible, its reliability should be confirmed. Since village dataset is an important input for the site selection, it was decided to verify this dataset using field verification approach. Here, simple field observation was followed where sites were selected randomly, but with controlled for inclusion of the village from different provinces and exclusion for the inaccessibility. Location of the surveyed village was obtained by using standalone GPS. Finally, NIS and SEILA data was compared.

Several of villages were selected from six provinces. The provinces are Svay Rieng, Battambang, Banteay Meanchey, Pursat, Otdar Meanchey, Siem Reap and Kandal. Map (Figure 3.2.3) shows the field survey locations with Star Mark in different surveyed provinces.



Source: JICA Study Team

Figure 3.2.3 Map Showing the Location of Surveyed Village

In southeast floodplain provinces, for example Svay Rieng, both Seila and NIS village data are more or less in agreement with each other (Table 3.2.2). The location and number of villages listed in both dataset are found on the ground.

Table 3.2.2 Comparative List of Surveyed Village in Svay Rieng Province

SEILA Data			NIS Data
ID	Village	Commune	ID
20070111	Sala Tean	Chrokhet	20070111
20070111	Sala Tean	Chrokhet	20070111
20010704	Prey Toup	Prey Angkunh	20010704
20010707	Prey Angkunh	Prey Angkunh	20010707
20010707	Prey Angkunh	Prey Angkunh	20010707
20010703	Chrey Thum	Prey Angkunh	20010703

Prepared by JICA Study Team

However, in northwest provinces, there are more villages listed in Seila than that of NIS dataset. For example in Otdar Meanchey province, there are many new villages found during the field survey (Table 3.2.3), which are present in Seila but not in NIS dataset.

Table 3.2.3 Comparative List of Surveyed Village in Otdar Meanchey Province

SEILA Data				NIS Data
ID	District	Commune	Village	ID
22040301	Samraong	Koun Kriel	Khtum	22040301
22040302	Samraong	Koun Kriel	Ta Man	22040302
22040303	Samraong	Koun Kriel	Thnal Bat	22040303
22040304	Samraong	Koun Kriel	Anlong Veaeng	22040304
22040305	Samraong	Koun Kriel	Trapeang Veaeng	22040305
22040306	Samraong	Koun Kriel	Thmei	22040306
22040307	Samraong	Koun Kriel	Trapeang Sleng	N/A
22040308	Samraong	Koun Kriel	Phong	N/A
22040309	Samraong	Koun Kriel	Kon Kreal	N/A
22040310	Samraong	Koun Kriel	Kirivorn	N/A
22040311	Samraong	Koun Kriel	Champa Sok	N/A
22040312	Samraong	Koun Kriel	Kok Prasat	N/A
22040313	Samraong	Koun Kriel	Ou Pork	N/A
22040314	Samraong	Koun Kriel	Chheu Krom	N/A
22040315	Samraong	Koun Kriel	Kdoul	N/A

Prepared by JICA Study Team

It has been learned that during the last general national census some areas in the northwest provinces were not accessible due to several factors, specifically security. Also some of the new settlement was popup where displaced people, due to conflict, were resettled after the census. So this is logical to have more villages in Seila data because it was recorded recently in year 2003. After comparing the NIS and Seila data, it has been recommended to use Seila data for this project.

3.2.7 Data Integration and Analysis

As illustrated before in the schematic flow of GIS database input/output (Figure 3.2.2), data can be searched using logical query. Also the data can be integrated either using Physical Overlaying method or Logical Integration of Attribute data. Furthermore, the advanced analysis can be performed using Models based upon mathematical algorithms or simple Criteria Formulation. For example Table 3.2.4 shows a simple criteria to select a candidate village that satisfy the set conditions.

Table 3.2.4 An Example of Village Selection Criteria for Rural Electrification

S. No.	Measure	Measuring Indicator (If the Indicator is available)	Village is Selected?	Weightage
1	Rural Poverty Level	Poverty Index??	NA	0.25
2	Sustainable Demand	House Hold (HH) Size of Village/Community	NA	0.25
3	Available Community Facility	Hospital, School and Local Gov. Office	Yes	NA
4	Willingness to have Electricity	HH having Battery Operated Lighting/TV	NA	0.25
5	Existing Grid Command Area	Physical distance between Village and Grid	No	NA
6	Accessibility	Physical distance between Village and Road	Yes	NA
7	Deprive Community	Minority and Ethnic Group for example	NA	0.25
8	For Mini-Hydro Station	Physical distance between Village and Perennial River/Lake	Yes	NA
9	Security	Land Mine and other Unexploded Ammunition	No	NA
10	Urban and Surrounding Area	Municipal, Provincial Capital and Area within 40km of Provincial Capital	No	NA

Source: JICA Study Team

Data analysis or query results in some sort of output. Such output can be new map with substantial change/improvement or with minor desirable modifications, tables, text report, etc. Until now, in the Study, several new thematic maps have been produced by simple manipulation of database created/compiled so far. The created maps also become part of the database itself.

3.2.8 Conclusion

Main structure of GIS database has been conceptualized and created. A number of data of various kinds has been added to the GIS database from various sources. In most of the cases the prime source of data is government ministry, specifically Ministry of Public Works and Transportation, Department of Forestry, National Institute of Statistics. Besides, SEILA, an INGO, provides very important village survey data of year 2003.

In order to confirm the data ambiguity between NIS and SEILA village location data, field survey was conducted. It has been concluded that being the most updated data, SEILA village data should be used in the Study.

3.3 SELECTION CRITERIA

The selection criteria are presented in Section 2.5 of Volume 3 Part 1 Manual for Updating Master Plan.

3.3.1 Screening of Village Electrification Schemes

By applying screening criterion given in Figure 2.4.2 of Sub-section 2.4.2, Volume 3 Part 1, 44 village electrification schemes were screened. As a result of screening, 21 schemes were classified to be electrified by micro hydro mini grid. Other 23 schemes were classified into “Battery Lighting” group as such schemes have lower battery diffusion level. Screened 21 schemes are listed in Table 3.3.1.

Table 3.3.1 Summary of Selected 21 Micro Hydro Schemes

No.	Name of RE Scheme	Target Villages					Micro Hydro					
		Sub No.	Province	District	Commune	Nos. of Villages Electrified by MHP (Plan)	Potential Dry Season Power (kW)	Nos. of house-holds	Nos. of HH to be Electri-fied	Total Demand incl. loss (kW)	Required Backup Capacity P_{mh} (kW)	Length of MV Trans. Lines (km)
1*	Sangke D/S	1	Battambang	Rotonak Mondol	Traeng	45	59	6,786	5429	706	562	115.0
	Sangke U/S	2	Battambang	Rotonak Mondol	Traeng	45	85					
2*	Sangke D/S (Alternative)	1	Battambang	Rotonak Mondol	Phlov Meas	8	59	1,324	1059	138	79	13.0
3*	Bay Srok	1	Ratanak Kiri	Lumphat	Ka Laeng	3	65	560	448	58	0	3.0
4*	Bu Sra	1	Mondul Kiri	Pech Chenda	Bu Sra	10	91	899	719	93	2	25.0
5*	O Sla D/S	1	Koh Kong	Kampong Seila	Kampong Seila	4	283	1,249	999	130	0	15.0
6*	Xtung Tun Po	1	Pursat	Veal Veaeng	Pramaoy	3	55	451	361	47	0	11.0
7*	Srae Cheng	1	Kampot	Chum Kiri	Srae Chaeng	1	6	284	227	30	24	8.0
8*	Tatai D/S	1	Koh Kong	Thma Bang	Ruessei Chrum	2	62	155	124	16	0	10.0
9*	Tributary Stung Cra Nhung	1	Battambang	Samlout	Ta Taok	14	330	844	675	88	0	33.0
10*	O Leach Meas	1	Pursat	Phnum Kravanh	Samraong	2	35	164	131	17	0	13.0
11*	Prek So Long Lower	1	Mondul Kiri	Kaev Seima	Srae Khtum	5	42	286	229	30	0	14.0
12*	Stung Thum	1	Kampong Chhnang	Tuek Phos	Chieb	1	14	107	86	11	0	2.5
13*	Ou Treb Da	1	Krong Preah Sihanouk	Prey Nob	Cheung Kou	1	165	61	49	6	0	8.0
14*	O Moleng	1	Mondul Kiri	Saen Monourom	Monourom	14	82	1,434	1147	149	15	5.0
15*	O Romis	2	Mondul Kiri	Saen Monourom	Monourom	14	19					1.5
16*	Prek Dak Deurr	3	Mondul Kiri	Saen Monourom	Sokh Dom	14	33					9.0
17*	Prek Dak Deurr D/S	4	Mondul Kiri	Saen Monourom	Sokh Dom	14	206	1,434	1147	149	0	4.5
18*	O Katieng	1	Ratanak Kiri	Lumphat	La Bang Muoy	4	* 40	295	236	31	0	6.5
19*	Stung Sva Slab	1	Kampong Speu	Phnum Sruoch	Chambak	4	56	665	532	69	13	12.0
20*	Stung Siem Reap U/S	1	Siem Reap	Svay Leu	Khnang Phnum	8	73	604	483	63	0	23.0
21*	Stung Siem Reap D/S	1	Siem Reap	Banteay Srei	Khun Ream	19	348	3,697	2958	385	37	55.0

Source: JICA Study Team

Among the above selected 21-micro hydro power (MHP) schemes, comments for schemes are described below:

Scheme No.14 - 16 : Proposed three-(3) schemes of MHP in Mondul Kiri province, which are "O Molen", "O Romis" and "Prek Dak Deurr", are now on-going study at the basic design stage by JICA for the Japanese grant aid-project (as of July, 2005). Therefore, these 3-schemes are not considered in this master plan.

Scheme No.17 : The downstream of "Prek Dak Duurr" (d/s) scheme in Mondul Kiri province is proposed as an alternative plan for the additional power supply to the above 3-project.

Scheme No.18 : According to the MIME, the proposed MHP scheme of "O Katieng" project in Ratank Kiri province will be study and implemented by UNIDO.

Scheme No.19 : The "Stung Sva Slab" was also proposed by Meritec study (2001). However, according to the results of field survey by JICA Study Team and MIME, the river flow in dry season was almost dried-up in April-May 2005. Therefore, for the off-grid electrification by MHP, it should be required the backup generator that is almost same capacity to MHP.

Scheme No.20 & 21 : The proposed schemes of "Stung Siem Riep" in Siem Riep province were studied previously, JICA Cambodia Office (2005) and Meritec (2001). However, there is a transmission extension plan from Thai to Siem Riep. This project will conducted by ASK company (BOT) and the power line construction will be complete in 2006. The target villages of No.20 & 21 schemes have also possibility to supply electricity from this transmission project.

3.4 SELECTION OF SCHEMES FOR PRE-FEASIBILITY STUDY

Selection of 10 Priority Schemes

A priority ranking study was carried out as described in Sections 3.1 to 3.3 hereof, to select top 30 schemes in total (10 from mini-grids of micro hydro, 10 from mini-grids of biomass, and 10 from solar BCS).

According to the provisions of M/M dated June 17, 2004, 10 electrification schemes/communes are to be selected first. Then one alternative is to be formulated for each of the 10 schemes prioritized, to make 20 alternatives in total. Site inspection is to be followed. Then 10 schemes are to be selected as candidates for village survey to examine suitability in view of the community capacity for undertaking operation and management of the electrification scheme unless it is managed by REE. The work flow is shown on the left side in Figure 3.4.1. On the other hand, it was required to the Master Plan Study to formulate electrification plans for each village (on village basis).

In the present study, of those 11,326 villages identified as situated in the off-grid area and summarized in Table 3.1.3, 60 prospective schemes were studied on map and surveyed in field, to formulate electrification schemes integrating multiple villages/communes. For the rest of the villages, electrification plans were prepared for each single village (on village basis).

The way specified in the M/M above to select 2 alternative villages for each of the 10 priority communes requires formulation of electrification plans on commune basis (not on village basis) and re-prioritization of such commune electrification schemes. (It will be required to prepare electrification plans in two ways, one on village basis and the other on commune basis. An attempt to formulate 2 alternatives in certain commune does not match the technical features. Potential site of micro hydro is immovable and target villages are determined from the potential and distribution of villages nearby. A biomass gasification power plant should better be placed in the center of target villages to minimize the distribution losses. A solar BCS should be placed to each village. These do not need alternative study on target villages but respective experts can work out a plan.) To avoid duplication in preparation and ranking of electrification plans between communes and villages, the selection sequence of 10 priority schemes is slightly modified as shown on the right side in Figure 3.4.1.

Table 3.4.1 presents a list of top ranked 10 priority schemes in the mini-grid group of micro hydro, Table 3.4.2 mini-grid group of biomass power, and Table 3.4.3 solar BCS group.

Table 3.4.1 Top 10 Mini-Grids by Micro Hydro and Hybrid, MP2005

No.	Province	Name of Plan	Energy Source	Methods	Nos. of hh for RE	Generation Capacity (kW)
1	Battambang	Sangke	MHP & Bio	Hybrid	5429	706 (MHP144, Bio562)
2	Ratanak Kiri	Bay Srok	MHP	Micro Hydro	448	58
3	Mondul Kiri	Bu Sra	MHP	Micro Hydro	719	93
4	Koh Kong	O Sla D/S	MHP	Micro Hydro	999	130
5	Pursat	Xtung Tun Po	MHP	Micro Hydro	361	47
6	Kampot	Srae Cheng	MHP & Bio	Hybrid	227	30 (MHP6, Bio24)
7	Koh Kong	Tatai D/S	MHP	Micro Hydro	124	16
8	Battambang	Tributary Stung Cra Nhung	MHP	Micro Hydro	675	88
9	Pursat	O Leach Meas	MHP	Micro Hydro	131	17
10	Mondul Kiri	Prek So Long Lower	MHP	Micro Hydro	229	30

Source: JICA Study Team

Table 3.4.2 Top 10 Mini-Grids by Biomass Gasification Power, MP2005

No.	Province	Name of Plan	Energy Source	Fuel	Nos. of hh for RE	Generation Capacity (kW)
1	Pursat	Phnum Kravanh Bio	Biomass	Planted Energy Tree	3142	408
2	Kampong Chhnang	Svay Bakav CF	Biomass	Planted Energy Tree	274	36
3	Kampong Thom	Kraya CF JICA	Biomass	Planted Energy Tree	858	112
4	Takeo	Takeo CelAgrid	Biomass	Planted Energy Tree	963	125
5	Kampong Cham	Krasang	Biomass	Planted Energy Tree	399	52
6	Kampong Thom	Chi Aok CF	Biomass	Planted Energy Tree	138	18
7	Battambang	Kbal Taol	Biomass	Planted Energy Tree	419	54
8	Kampong Cham	Batheay	Biomass	Planted Energy Tree	594	77
9	Siem Reap	Phum Prampir	Biomass	Planted Energy Tree	285	37
10	Kampong Chhnang	Meanok FA Plantation	Biomass	Planted Energy Tree	509	66

Source: JICA Study Team

Table 3.4.3 Top 10 Solar BCS, MP2005

No.	Province	Name of Plan	Energy Source	Scheme	Nos of hh for RE	Generation Capacity (kWp)
1	Stung Treng	Srae Ta Pan	Solar	Solar BCS	76	4
2	Ratanak Kiri	Kaoh Peak	Solar	Solar BCS	142	6
3	Kampong Thom	Koun Tnaot	Solar	Solar BCS	87	4
4	Mondul Kiri	Pu Hiem	Solar	Solar BCS	200	9
5	Stung Treng	Man	Solar	Solar BCS	130	6
6	Ratanak Kiri	Ta Ang Pok	Solar	Solar BCS	105	5
7	Ratanak Kiri	La Meuy	Solar	Solar BCS	82	4
8	Mondul Kiri	Pohourn	Solar	Solar BCS	80	4
9	Ratanak Kiri	Kok Lak	Solar	Solar BCS	51	3
10	Mondul Kiri	Pokes	Solar	Solar BCS	75	4

Source: JICA Study Team

Ratio of target village numbers of mini-grids and solar BCS is about 4:1. With reference to this ratio, 8 schemes are selected from the mini-grid group by renewable energy (micro hydro and biomass power) and 2 schemes from solar BCS group. Since micro hydro and biomass mini-grids are two main vehicles for electrification of the off-grid areas, the same number of 4 schemes each is selected from micro hydro and biomass group respectively.

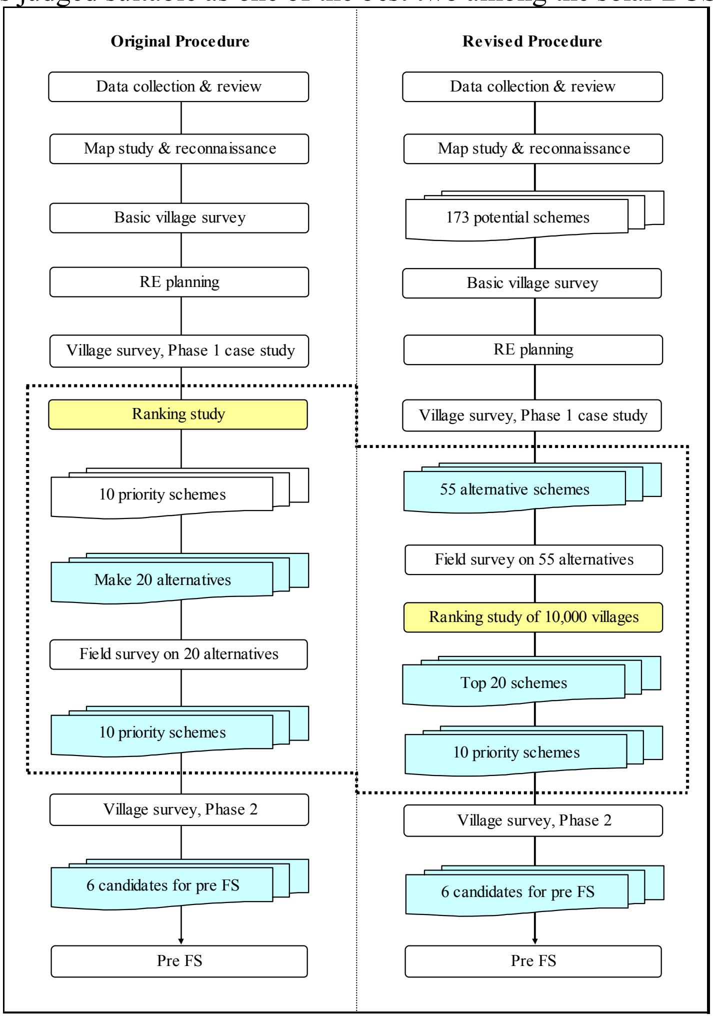
Among the 10 micro hydro group given in Table 3.4.1, the 4th ranked O Sla D/S scheme in Koh Kong Province was excluded from the further examination of pre-FS candidates since it was known on 6 July that a Korean company had submitted a proposal for feasibility study on this scheme to the government in the end of June 2005. The O Sla scheme in the Koh Kong Province targeting 4 villages in Kampong Seila is situated outside PAGE of 40 km in radius from the provincial capital. There is no electrification plan by the Kirirom 3 hydropower project (15 MW in installed capacity), which will be implemented by an IPP to feed the Phnom Penh grid (This was confirmed by an EdC officer at a coordination meeting held on 7 June 2005). Accordingly, the Kampong Seila commune would not be electrified by grid extension and have a high priority for electrification by mini-grid.

Accordingly, the 5th ranked Xtung Tun Po scheme in Pursat Province is included as one of the best four among the micro hydro group and is included in Table 3.4.4.

As for the biomass mini-grid group, the top ranked 4 schemes are considered the best four and are included also in Table 3.4.4.

As for the solar BCS group, the 1st ranked Srae Ta Pan scheme in Stung Treng Province and the 7th ranked La Meuy scheme in Ratnak Kiri Province are selected as the best two among the solar BCS group and are included in Table 3.4.4 based on the following consideration:

1) Srae Ta Pan scheme in Stung Treng Province (ranked at 1st in Table 3.4.3) has a battery diffusion level at 3% and no BCS in the village (village survey in early July 2005). This scheme is judged suitable as one of the best two among the solar BCS group.



Source: JICA Study Team

Figure 3.4.1 Work Flow of Selecting Six Candidates for Pre-Feasibility Study

2) The schemes ranked 2nd, 5th, 8th, and 10th have no access road and would need walking or bike-ride to approach the site. This would incur some risk of causing difficulty in site survey, construction works, and monitoring if these are selected as candidates for pre-feasibility study. These are, therefore, screened out from further examination.

3) The 3rd ranked Koun Tnaot scheme in Kampong Thom Province has a grid electrification level at 0% and TV diffusion level at 0%. However, its battery diffusion level is 81% which contradicts with the TV diffusion level. In view of the relatively short distance of 15 km from the provincial capital and its location along a main road in the region, the village is likely to have a high level of battery diffusion. The literacy level is low at 33%.

   According to a village inspection made in late June 2005, it is confirmed that the battery diffusion level is about 30% and there is no BCS in the village. However, there are collection, charging, and delivery services of battery. This village is not suitable as priority scheme in the solar BCS group.

4) The schemes ranked 7th and 9th are appropriate in terms of the low level of battery diffusion. It is located at about 30 km far from the provincial capital and needs river crossing by boat since these are located on the right bank of the Sesan River. It has been confirmed by the village inspection made in early July 2005 that the La Meuy scheme (7th ranked) in Ratnak Kiri Province has a battery diffusion level at 3% and no BCS in the village. A boat can be used for accessing the village except during flooding time. This is suitable as a priority scheme from among the solar BCS group.

5) The 9th ranked Kok Lak scheme could not be surveyed in early July 2005 because villagers went to fields for paddy transplanting and could not communicate in Khmer. It has no BCS. This scheme appears suitable but needs further clarification of battery diffusion level before taking it up as one of the best two from among the solar BCS group.

6) The 4th ranked Pu Hiem shceme in Mondul Kiri Province has a relatively high TV diffusion level at 7.6% compared to a low level of battery diffusion at 0.4%, which contradicts to each other. The diffusion level was confirmed to be 57% through a village inspection made in early July 2005. This is not suitable as a priority scheme of the solar BCS group. It can be promoted rather with a mini-grid.

7) The 6th ranked Ta Ang Pok scheme in Ratnak Kiri Province has a battery diffusion level at 10% according to a village inspection made in early July 2005. It has no BCS. There was a small diesel generator but scraped after having machine trouble and the villagers are using battery now. The battery diffusion level is relatively high and is not very suitable as a priority scheme of solar BCS. Accordingly, the scheme is screened out from the further examination.

8) As a result of the examination above, the 1st ranked Srae Ta Pan scheme in Stung Treng Province and the 7th ranked La Meuy shceme in Ratnak Kiri Province has the high priority from the two viewpoints of their low battery diffusion level at 3% and no BCS existing inside the village.

   The two schemes above have grid electrification level at 0%, battery diffusion level at 3%, accessible by road (the Srae Ta Pan scheme needs river crossing but a ferry services on the national road is also available for transportation of materials and equipment.), village scale is 95 and 102 households respectively (in Table 3.4.4, 80% of the households are assumed to receive electricity), the literacy level is low at 12% and 23% respectively. Accordingly, installation of solar BCS in these villages can be expected to contribute to reducing the poverty.

The top 10 schemes thus selected from among the 30 schemes in total (10 each from mini-grids by micro hydro, mini-grids by biomass, and solar BCS group) are given in Table 3.4.4.

Table 3.4.4 Top 10 Priority Projects

No.	Province	Name of Scheme	Type	Nos of hh to Electrify	Installed Capacity (kW)
Micro Hydro Power					
1	Battambang	Sangke	Mini Grid	5,429	706 (MHP144, Bio562)
2	Ratanak Kiri	Bay Srok	Mini Grid	448	58
3	Mondul Kiri	Bu Sra	Mini Grid	719	93
4	Pursat	Xtung Tun Po	Mini Grid	361	47
Biomass Power					
1	Pursat	Phnum Kravanh Bio	Mini Grid	3,142	408
2	Kampong Chhnang	Svay Bakav CF	Mini Grid	274	36
3	Kampong Thom	Kraya CF JICA	Mini Grid	858	112
4	Takeo	Takeo CelAgrid	Mini Grid	963	125
Solar Power					
1	Stung Treng	Srae Ta Pan	Solar	76	4
2	Ratanak Kiri	La Meuy	Solar	82	4
Total	-	-	-	12,352	1,593

Source: JICA Study Team

Most of the top 10 schemes selected were inspected in the field. After examination of the top 10 schemes based on the field survey results, it is judged that the top 10 schemes (4 from micro hydro, 4 from biomass, and 2 from solar power) have no specific issue as candidates for the village survey, Phase 2 case study.

<u>Selection criteria of six pre-FS schemes</u>

Through the study described in the foregoing section, the top 10 schemes have been selected as shown in Table 3.4.4. It is proposed that the Phase 2 village study be started on these 10 villages.

(1) Number of schemes for pre-feasibility study

M/M prescribed the number of schemes for pre-feasibility study as quoted below:

The pre-feasibility studies would be carried out for six sites of renewable energy development: three of mini- or micro-hydropower sites and three photovoltaic sites. However, if any other measures are superior to the photovoltaic sites, both sides would discuss to change the measures for electrification of the villages to wind, biomass, biogas or hybrid systems.

The Study Team held a coordination meeting on 10 June 2005 with a specific topic on the biomass gasification power. The proposed approach to the electrification of the off-grid areas with mini-grids by biomass power has been supported by the participants with some comments including one stressing the importance of the coordination among the relevant ministries concerned. The Draft Interim Report was explained to the JICA Headquarter in Tokyo on 6 July and was accepted with several important comments.

Based on the above, the six schemes for pre-feasibility study are selected as follows:

1) The number of schemes by source of energy is set as show below in view of the potential in Cambodia, features of their geographic distribution, and commonly applicable feature of pre-feasibility study of solar BCS:
   - 3 mini-grids by micro hydro;
   - 2 mini-grid by biomass gasification power; and
   - 1 solar BCS.

2) The JICA Study Team once considered to take up 4 schemes from micro hydro group. However, along with the study progress, it has been clear that the potential sites are limited to those mountainous areas where villages are sparsely distributed and population density is low. It is then judged that the number of micro hydro should be 3 as originally envisaged in the M/M.

3) Of the rest 3, one each should be selected from the solar BCS and biomass power since these are the recommended way of electrification in the off-grid area. It is proposed that the last one scheme be selected from biomass group (2 in total) in view of the following points:

- Most of mini-grids to be installed in the off-grid area will be energized by biomass gasification power. Of a total of 8,732 villages screened for electrification with mini-grids, 3,071 villages or 35% are expected to be powered by biomass. In addition, 3,257 villages or 37% are expected to be powered either by grid extension or by mini-grids of biomass power.
- The biomass gasification power has three types of poroposed fuel biomass arrangement and is, therefore, desirable to study on 3 schemes if possible.

4) Although it was envisaged that 3 photovoltaic shcemes were taken up, one solar BCS shceme is selected based on the following consideration, to study on organizational set up as primary theme of the pre-feasibility study:

- Technical features of solar BCS have a high applicability to other sites since it is not site specific in its nature. Therefore, even only one shceme is studied, its pre-feasibility report can be referred to as a model in the planning of other solar BCS schemes.
- A main issue is to establish a village organization to operate and manage the solar BCS installed and training thereon.
- According to the field survey by the Study Team from December 2004 to 5 July 2005, no village has been found that have no battery lighting at all. The actual number of villages that have no battery at all would be very low.

5) The biomass gasification power will be a main source of energy for electrification in the off-grid area in plain area in particular where no hydro potential exists. The fuel arrangement is a main issue, followed by establishment of village organization if it is implemented under village-initiative. Three fuel supply sources are proposed:

- Fuel wood farming;
- Supply from community forest, including tree farming;
- Agricultural wastes such as rice husks, peanut shells, corncobs, etc.

It is desirable to study on the fuel supply plan for the three fuel sources above. The issue of fuel arrangement will be studied at pre-feasibility level on the 2 schemes selected.

(2) Criteria for selection of schemes for pre-feasibility study

The proposed selection criteria are as follows:

1) Adequate number of the beneficiary as a grant project of GOJ;

2) New electrification of non-electrified villages is given higher priority than improvement of existing mini-grids or conversion of existing diesel BCS to solar BCS (the latter has no impact as the first lighting to the village);

3) Location in conformity with the assistance strategy of the JICA Cambodia office.

(3) Six schemes for pre-feasibility study

It is proposed that the six schemes be selected out of the 10 priority schemes as shown in Table 4.2.1 hereof and described below:

1) Of the 4 candidates from the micro hydro given in Table 3.4.4, the Bay Srok scheme in Ratnak Kiri Province covers, in its service area, a village formed by labors engaged in gem mining. There is an ultimate possibility of disappearing of the village following gradual decrease in the population after passing the peak of gem production. There are many immigrants from Vietnam as well as migrants. The priority as a grant project to Cambodia would be rather low. In view of these points, the Bay Srok scheme was excluded from the further list. (Such situation was found and confirmed by site survey. It is difficult to take into such unusual social situation in the ranking criteria designed targeting all the villages in the country. It is an example to show a limit of priority ranking of so many villages simply based on the village database information. It suggests the importance of village survey on site.)

2) Of the other 3 micro hydro schemes, Bu Sra scheme will be the most economic if the Bu Sra waterfalls are harnessed. However, the waterfalls are valuable tourism resources of the region and need a careful planning. On a village survey by the Study Team, the villagers showed their such solution that the issue can be coped with by starting power generation from after 5:00 p.m. (Tourists presently visit the waterfalls and return to the provincial capital within the same day since there are no lodging facilities in the Bu Sra commune.) If the use of the Bu Sra waterfalls is not possible by all means, it is possible to harness the hydro potential on the adjacent river O Phlai. The scheme is suitable as a candidate for pre-feasibility study.

3) Pramaoy scheme in Pursat Province (Veal Veng District) is an electrification example of district town by mini-grid which is more than 100 km away from provincial capital, Pursat. Under such geographical condition, the area has very less possibility of electrification by grid extension from provincial town. As this scheme was selected at the last stage of master plan, the first field survey for this scheme started from July 2005.

4) The Samlout scheme in the Battambang Province (Samlout District) is a hybrid scheme of micro hydro and biomass power. It covers more than 5,000 households in the region and the social project benefit is significant. The area is situated outside PAGE of 40 km in radius from Battambang. Although it is covered by PAGE centered at Pailin, a grid extension from Pailin to the Samlout area would have a technical difficulty because the Pailin grid is receiving power by a MV line already extended from Thailand. Furthermore, since there are few villages in between Pailin and Sangke, an extension to Sangke would be economically inefficient.

   The head of the Sangke micro hydro scheme was surveyed preliminarily but it requires a further topographic survey. The land is fertile and suitable for growing fuel trees for the biomass scheme. Peanut shells and corncobs are available also as seasonal fuel sources. Since the area is wide, 22 kV distribution lines are essential. In the most distant part in the area, an REE is operating a diesel mini-grid for about 100 households. It will be extended to cover several 100s households. Upon arrival of the 22 kV lines of the Sangke scheme in this REE grid, the owner has an idea to continue his business under retail license. It is also possible to implement the Sangke scheme in multi-stage. The Sangke scheme is suitable as a candidate for pre-feasibility study.

5) As the 2 mini-grids by biomass gasification power, the Samraong scheme in the Pursat Province (1,229 households) and the Kampong Kor scheme in the Kratie Province (886 households) are selected.

   The Samraong scheme covers 4 villages situated in a narrow area and around 900 households. It has a high efficiency in electrification and high social project benefit according to a study on village maps at a scale of 1:100,000 developed by the Study Team (economic superiority will be studied at pre-feasibility study). It has a high value to implement a feasibility study as a model of fuel wood growing type. The priority of grid extension to Samraong is low because of its distance of about 30 km from the provincial capital as well as from the village distribution in the Pursat Province.

If an implementation of HV transmission line network around the Tonle Sap, of which feasibility study was completed in June 2005 by a Korean company, is shortly started, a plan to extend 22 kV lines to all the district towns becomes realistic. In that case, Samraong will sooner or later be connected to the national grid. However, the mini-grids recommended in the Master Plan will not conflict with the grid connection. It has been taken into a mini-grid planning to connect sooner or later to the national grid. In the medium to large mini-grids in particular, extra energy of the mini-grids generated by clean renewable energy in daytime can be sold to EdC. The Samraong scheme can be a pilot model of such energy sales to the national grid. The plant factor of mini-grids will remain at about 10% because its main demand is usually limited to nighttime lighting. The required tariff level would be $0.35/kWh even with financial support including soft loans and guarantee. After connection to the national grid, the plant factor will in general be improved to above 50%, subject to the quality of generating equipment. The unit generation cost after the grid connection will lower to below $0.10/kWh and the tariff level can be lowered to the level of EdC or even lower.

Kampong Kor scheme will be a model of mini-grids fueled from community forest. It is expected to be a model for avoiding pressure of illegal cutting to forest resources, management of forest and fuel wood by the community, and management of electricity business. This scheme can be implemented by staging into to 2 phases of original area electrification and extension plans. The scheme is suitable as a candidate for pre-feasibility study.

As for the other two schemes of biomass mini-grids, the Svay Vakav community forest scheme in Kampong Chhnang province has a small scale and the Takeo scheme in Takeo Province is relatively close to the national grid. These two are reserved as the future candidates for implementation.

6) Among the solar BCS, the Srae Ta Pan scheme in Stung Treng province is selected as a candidate for pre-feasibility study. The battery diffusion level is 3% (3 out of the 93 households have battery). There is no BCS in the village. People cross the Sesan River by a boat to charge their batteries at a BCS in a village on the opposite bank. The scheme is suitable as a candidate for pre-feasibility study.

All the schemes above are new electrification. Phase 2 village survey will be executed in July/August 2005. It is proposed that the six projects be reviewed in September 2005 based on the village survey results at the beginning of the 4th field assignment of the JICA Study Team.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The Master Plan 2005 has been prepared through the four month field survey (December 2004, January 2005, and May and June 2005). The following studies, analyses, and field surveys were conducted by respective experts/teams:

1) Institutional study and economic/financial analysis;
2) Grid extension study;
3) Map study and field survey including leveling survey, discharge measurements, and installation of stream gauging staff, by micro hydro team;
4) Data collection and field survey of biomass gasification power including biomass growth survey in Battambang and Kanpong Chhnang, sampling for suitability tests for gasification and nutrient sustainability, by biomass expert;
5) Data collection and field survey by solar/wind expert including calibration of satellite data on solar irradiation;
6) Social and village survey;
7) Environmental survey;
8) Preparation of GIS database.

As a result, the Master Plan was prepared. Intensive database and mapping works were carried out with GIS to develop various maps. These are available on the server of the MIME. The GIS database can be commonly utilized among MIME, EAC, and EdC.

Through the study, the following issues have been identified, and studied further and clarified in the assignments in September and December 2005:

1) An institution to support rural electrification should be discussed and agreed among the stakeholders concerned.
2) A new institution is required to be established to facilitate energy trade between EdC and sub-grids of REE/CEC connected to the national grid.
3) A nationwide village survey on electrification level should be carried out every year to facilitate monitoring of the progress of the Master Plan as well as its updating. It is recommended that the survey be entrusted to and undertaken either by NIS or Seila as part of their routine survey by adding the minimum number of survey items on village electrification.
4) Implementation of model schemes is needed to disseminate information on the new technology of biomass gasification power in particular.
5) In order to disseminate information on the Master Plan, it is desirable that a visual guide or manual be prepared in Khmer and distributed to all the communes, DIME, NGO, REE, banks, and other relevant stakeholders.
6) Further practical research and testing in relation to biomass gasification power are recommended.

4.2 SIX SCHEMES RECOMMENDED FOR PRE-FEASIBILITY STUDY

The six schemes listed in Table 4.2.1 are selected through the study as candidates for the pre-feasibility study. These were reviewed based on the Phase 2 village survey carried out in July/August 2005 on the 10 priority schemes.

Table 4.2.1 Six Candidate Schemes for Pre-feasibility Study

No.	Province	Name of Scheme	Type	Nos. of hh to Electrify	Installed Capacity (kW)
Micro Hydro Power					
1	Battam bang	Samlout	Hybrid	4,216	582
2	Mondul Kiri	Bu Sra	Mini-grid	936	80
3	Pursat	Pramaoy	Hybrid	334	45
Biomass Power					
4	Pursat	Samraong	Fuel wood farming	1,230	180
5	Kratie	Kampong Kor	Community forest	4,882	640
Solar Power					
6	Stung Treng	Srae Ta Pan	BCS + PV system	89	4
Total	-	-	-	11,687	1,531

Source: JICA Study Team

4.3 INSTITUTIONS AND ORGANIZATIONS RECOMMENDED FOR PROMOTING IMPLEMENTATION

4.3.1 Recommendations on Institutional and Financial Framework

(1) To improve environments for investing in RET-based RE projects

- to provide reduction/exemption of import duties of RET equipment
- to provide financial incentives to encourage the existing REEs switch over the diesel-based generation to RET-based generation using the improved REF financial support mechanism as mentioned below.
- to provide the REEs and CECs access to long-term institutional credit mechanism (smart credit) using ODA loan-based two-step lending scheme

(2) To reinforce and strengthen functions of REF

The REF should be provided with the following mandates to promote the rural electrification development.

- to provide several options of grant facilities in addition to the existing uniform grant facility (grant 25%, equity 25% and loan 50%) depending types of electrification, types of components, usage of RETs and types of ownerships as discussed in Chaps. 1.7.3 and 2.2.2 of Part 2
- to provide loan guarantee for financial institutions by REF to provide loan guarantee for financial institutions by REF

- to coordinate with and strengthen linkage to EdC and EAC for provision of technical assistance to private developers (REEs and CECs)

4.3.2 Recommendations on Implementation Organization

There are many stakeholders involved in the implementation of rural electrification. The implementation responsibilities of the stakeholders shall be as given in the following table. The electricity providers in rural areas will be three entities: EdC, REE and CEC.

Table 4.3.1 Implementation Responsibility of Stakeholders

Business Model	Ownership	Operation	Training and Facilitation	Approval	Licensing and Regulation
EdC	EdC	EdC or REE	-	MIME/REF	EAC
REE	REE	REE	EdC or NGO	MIME/REF	EAC
CEC	CEC	CEC	NGO	MIME or MRD	EAC
Solar BCS/SHS	MIME	CEC or REE	MIME or NGO	-	-
REU	Local Gov't	Own force or REE	EdC	MIME	EAC

Source: JICA Study Team

4.3.3 Recommendations on Personnel Development and Capacity Building

It is the personnel to move and work the organization and institutions recommended. So it is important to secure the personnel who is able and capable enough to implement the electrification businesses. Here we make recommendations on how to educate and train major entities concerned, including (i) communities, (ii) REEs and CECs, and (iii) Governments (MIME/DIME)

IEC Activities by Governments for communities and REE/CEC

The Governments (MIME and DIME) shall extend wide scale information, education and communication (IEC) activities to diffuse knowledge and best practices of RETs as well as to encourage active and organized participation by community beneficiaries. More concrete activities include the following:

- to distribute and diffuse "the Visual Guides" produced by the JICA Study Team
- to hold seminars/workshops for REE/CEC/NGO
- to publish the contents of the seminars/workshops in the form of technical notes
- to publish RET news (periodicals/circulars)
- to establish RET Consultation Room in MIME's Technical Energy Department
- to install a website on RET and disseminate information on it
- to establish branch offices in each DIME office to meeting local needs and requests
- to conduct applied research and organized dissemination of new RETs for Cambodia (setting up a new organization like "Biomass Center" as the needs be)
- to implement pilot projects using replicable technologies and business models

- to prepare technical standards and codes on RET-based RE (for ensuring safety and quality of services)

Capacity Building for REE/CEC

The Governments (MIME/DIME) and the funding agencies (REF/CFR) shall provide REE and CEC with various trainings so as to enable them to run the business by engaging NGO and consultants. The areas of training needs include:

- project planning (feasibility study)
- engineering and procurement (design and construction)
- project management (supervision)
- maintenance and repair
- operation (production and revenue collection)
- expansion for future needs

MIME/DIME should tie up with EdC, NGO and consultants to provide the training to REE and CEC. Especially, the technical training at the existing EdC training center in Phnom Penh should be reinforced and expanded for this purposes.

Capacity Building for Government Agencies

The government agencies (MIME/DIME, etc) facilitating the private sector (REE/CEC and NGO) also need to build capacities for implementing the policies and investment plans. The areas of capacity building include:

- to design implementation rules and regulations for RE development
- to clearly identify and define the risks and mitigation measures shared by the government and private sector
- to make RFP (request for proposals), proposal evaluation, contract management, performance monitoring and implementation support for REE/CEC
- to delegate to and build capacities of local government officials

The World Bank already committed provision of technical assistance on institutional strengthening and capacity building of REF and MIME. The Government is recommended to make a request for Japan's ODA assistance for the remaining capacity building needs, including improving computer systems, Biomass Center, pilot project implementation, RET standards and codes, etc.

And lastly but very important recommendation is the public officials salaries should be improved. This will be most effective means of governance improvement. Too low civil service salaries are inconsistent with sustainable government capacity building. With this improvement, the government officers do not have to live off afternoon side works, so that they are able to concentrate on the full-scale IEC activities as recommend above. However, this is a national issue of RGC, and rectification is thought to be a slow process. As a short-term countermeasure, it is proposed to include as part of the financing assistance, remuneration for technical services provided by DIME and others.

4.4 REVIEW AND UPDATING OF MASTER PLAN

The Master Plan 2005 should be updated every four years in accordance to the Manual presented in Volume 3 Part 1.