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Japan International Cooperation Agency (JICA)

Ministry of Electric Power
Myanma Electric Power Enterprise
Union of Myanmar

The Study on Introduction of Renewable Energies in Rural Areas in Myanmar

Final Report

Volume 3 Main Report

Guidelines for Rural Electrification

September 2003

Nippon Koei Co., Ltd.
Institute of Energy Economics Japan

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MYANMA ELECTRIC POWER ENTERPRISE
MINISTRY OF ELECTRIC POWER
UNION OF MYANMAR

THE STUDY ON INTRODUCTION OF RENEWABLE ENERGIES
IN RURAL AREAS IN MYANMAR

FINAL REPORT

VOLUME 3

MAIN REPORT

GUIDELINES FOR
RURAL ELECTRIFICATION

SEPTEMBER 2003

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
INSTITUTE OF ENERGY ECONOMICS, JAPAN

PREFACE

In response to a request from the Government of the Union of Myanmar, the Government of Japan decided to conduct the Study on Introduction of Renewable Energies in Rural Areas in Myanmar and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA dispatched a study team to the Union of Myanmar organized by NIPPON KOEI Co., Ltd. (NK) and the Institute of Energy Economics, Japan. The team was headed by Mr. Akio KATAYAMA of NK and visited Myanmar nine times from January 2001 through to August 2003.

The study team held a series of discussions with the officials concerned of the Government of the Union of Myanmar and, in conjunction with counterparts from the Myanma Electric Power Enterprise (MEPE), conducted field surveys and monitoring of an existing small MEPE hydropower station. The study team also carried out studies in Japan and compiled the final results in this Final Report.

I hope this report will contribute to improving the level of rural electrification and thereby contribute to alleviating poverty and reducing the urban-rural divide in Myanmar, and also to enhancing the amity between our two countries.

I express my sincere appreciation to the officials concerned of the Government of the Union of Myanmar for the cooperation they extended to the study team throughout the study.

September 2003

Takao KAWAKAMI
President
Japan International Cooperation Agency

September 2003

To Mr. Takao KAWAKAMI
President
Japan International Cooperation Agency (JICA)
Tokyo, JAPAN

Dear Sir,

Letter of Transmittal

We are pleased to submit herewith the Final Report of the Study on Introduction of Renewable Energies in Rural Areas in Myanmar. The report reflects opinions and views of the Myanma Electric Power Enterprise and other organizations concerned in Myanmar, as well as Japanese government organizations concerned.

In view of the power supply conditions in Myanmar—severe shortages have been experienced even in the capital city Yangon—we propose in our conclusions that renewable energy be extensively introduced in the rural areas by utilizing local technology existing and available in Myanmar. We hope and believe these *Guidelines*, *Manuals*, *Development Plans*, and *Database* will be useful and employed in the implementation, operation and maintenance of rural electrification projects, both *Government Schemes* and *Village Schemes*, for sustainable improvement of the level of rural electrification that would contribute to rural poverty alleviation and reduction of the urban-rural divide in Myanmar.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of Economy, Trade and Industry, Japan for extensive support and cooperation.

We also wish to express our deep gratitude to the Ministry of Electric Power, Department of Electric Power, and Myanma Electric Power Enterprise for the cooperation extended to our study team throughout the field surveys and studies in Myanmar.

Very truly yours,

Akio KATAYAMA, Team Leader
The Study on Introduction of Renewable Energy in Rural Areas in Myanmar

Nippon Koei Co., Ltd.
Institute of Energy Economics, Japan

THE STUDY ON INTRODUCTION OF RENEWABLE ENERGIES
IN RURAL AREAS IN MYANMAR

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ABBREVIATIONS

Organizations

DEP, DOEP	Department of Electric Power of MOEP
DHP	Department of Hydroelectric Power of MOEP
GOM/SPDC	Government of Myanmar/State Peace and Development Council
GOJ	Government of Japan
ID	Irrigation Department of Myanmar
IOE	Institute of Economics of Myanmar
ITC	Irrigation Technology Centre, Irrigation Department
JICA	Japan International Cooperation Agency
MADB	Myanma Agricultural Development Bank
MAPT	Ministry of Agricultural Products and Trade
MEC	Myanmar Economic Commission
MELC	Myanma Electric Light Co-operative Society Ltd.
MEPE	Myanma Electric Power Enterprise
MPBANRDA	Ministry for Progress of Border Areas and National Races and Development Affairs
MOC	Ministry of Cooperatives
MOE	Ministry of Energy
MOEP	Ministry of Electric Power
MOST	Ministry of Science and Technology
MSTRD	Myanma Scientific and Technological Research Department
NCEA	National Commission for Environmental Affairs
NEDO	New Energy & Industrial Technology Development Organization, Japan
SPICL	Sein Pann Industrial Production Co-operative Limited
USDA	Union Solidarity and Development Association (an NGO)
VEC	Village Electrification Committee
VPDC	Village Peace and Development Council
YIE	Yangon Institute of Economics
YIT	Yangon Institute of Technology

Economics, Finance

ATP	Ability to Pay
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
IRR	Internal Rate of Return
WTP	Willingness to Pay

Unit

kVA	kilo Volt ampere
kWh	kilo-Watt-hour
MWh	Mega-Watt-hour (10^3 kWh)
K	Currency unit of Myanmar (Kyat)
toe	Tons of oil equivalent (10^7 kcal)
US$, $	Currency unit of USA (US dollar)
Yen	Currency unit of Japan (Yen)

Others

BCS	Battery Charging Station
FS	Feasibility Study
HRD	Human Resource Development
IPP	Independent Power Producer
MP	Master Plan
NGO	Non Governmental Organization
OJT	On-the-Job-Training
O&M	Operation and Maintenance
R&D	Research and Development
RE	Rural Electrification
SHS	Solar Home System

Exchange Rates

US$ 1.00 = K500 = Yen 120 (May 2001)
US$ 1.00 = K1,000 = Yen 120 (May 2003)
unless otherwise specifically noted

HOW TO USE THE GUIDELINES

Who are the Guidelines for?

The Guidelines aim at serving those staff of the proposed Section for Rural Electrification (SRE) in the MEPE Transmission and Distribution Dept., Divisional/State Offices and Township Offices of MEPE, in order to promote decentralized rural electrification (RE) in the rural area of Myanmar using Renewable Energy (*Government RE Scheme*s). The Guidelines also aim at serving those villagers who wish to implement electrification of their village on a self-help basis (*Village RE Schemes*). These would also help private sector experts who support and assist such rural electrification, in the selection of a suitable form of renewable energy and formulating a basic concept for the electrification of the target village.

What is the purpose of the Guidelines?

The Guidelines provide basic information and criteria to facilitate identification of the needs for the electrification of potential villages. They demonstrate the potential of renewable energy such as small hydro, biomass, solar, and wind power. They also facilitate the selection of the suitable form of renewable energy to the village of interest, and assist preliminary planning of rural electrification on a self-help basis.

Are there any other references?

As part of the Study, the following references are prepared and available for the MEPE staff. These would also help villagers, private sector experts and NGOs as well:

- Visual Guide, English version as Appendix to Vol. 1 Summary, Myanma version in a separate volume, presenting illustrative charts on:
  - What is the renewable energy useful for rural electrification?
  - What level of electrification can be realized?
  - What is the renewable energy suitable for specific region?
  - How to estimate the potential of renewable energy?
  - What is the cost range?
  - Visual Manual of *Village Hydros* (<50 kW) for planning and designing.
- Manuals for Sustainable Hydros, Vol. 4:
  - It covers both small hydros (>50 kW) to be implemented by MEPE and *Village Hydros* (<50 kW) by villagers.

PART 1 INTRODUCTION

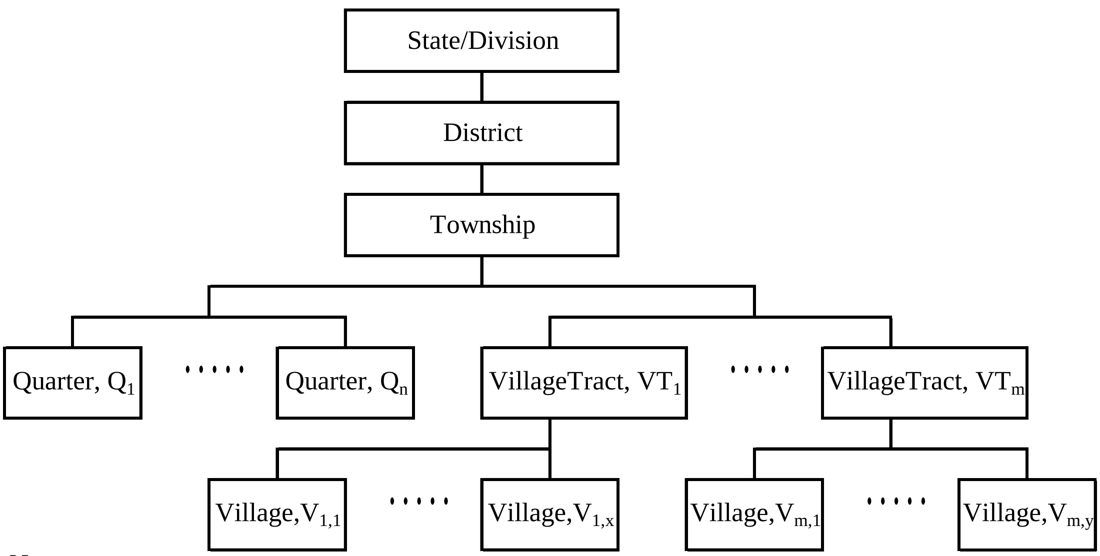
The Guidelines are prepared as the first output of the Study on Introduction of Renewable Energies in Rural Areas in Myanmar (the Study). The Study was started in January 2001 in accordance with the Scope of Work and Minutes of Meeting which were exchanged by the Ministry of Electric Power of Myanmar (MOEP), Myanma Electric Power Enterprise (MEPE), and Japan International Cooperation Agency (JICA) on September 21, 2000. The Study was completed in September 2003.

1. Needs for Electrification

1.1 Current Status of Rural Electrification in Myanmar

(1) Administration Structure in Myanmar

As illustrated in Figure 1, the administrative structure in Myanmar consists of states/divisions at top level, and districts, townships, quarters (or wards), village tracts, and villages. As of year 2000, the number of districts is 64, townships 324, and village tracts 13,792.



Note:

$Q_1 \cdots Q_n$: The first Quarter to n-th Quarter

$VT_1 \cdots VT_m$: The first Village Tract to m-th Village Tract

$V_{1,1} \cdots V_{1,x}$: The first Village to x-th Village of the first Village Tract

$V_{m,1} \cdots V_{m,x}$: The first Village to the y-th Village of the m-th Village Tract

Source: JICA Study Team

Figure 1 Administration Structure in Myanmar

Most of the townships have population over 10,000. Its central part consists of several quarters (wards). Village tract is a group of various sizes of villages geographically bordering to each other. Village tracts are under administrative control of the chairman of Township Peace and Development Council (TPDC). The chairman of village tract is selected from among about four village Management Members who are to be elected from chiefs of all the member villages under the village tract. The chairman of village tract may also be appointed by SPDC. Depending on the scale of villages, one village management member represents 1,000-2,000 villagers in general.

There is no written rule on the terms of the services of the chairman of village tract and village chief. They are unpaid volunteers. The chairman of village tract usually changes in 3-6 years.

The characteristics of rural areas of Myanmar are summarized in Appendix-5.

(2) Level of Rural Electrification

Figure 2 presents population and rural electrification level (excluding urban areas/ quarters/wards) of the 14 states and divisions in Myanmar.

The gap of electrification level is very large between urban areas and rural areas. According to a Household Income and Expenditure Survey made by Central Statistical Organization in 1997, 37% of the households have electricity, 24% have to use battery. In urban Myanmar 72% have electricity and 10% use battery. In rural Myanmar 18% have electricity and 32% use battery. Among urban states and divisions, Magway division has the highest percentage (92.5%) of households with electricity. Among rural states and divisions, Rakhine state has the lowest percentage (2.3%) with electricity.

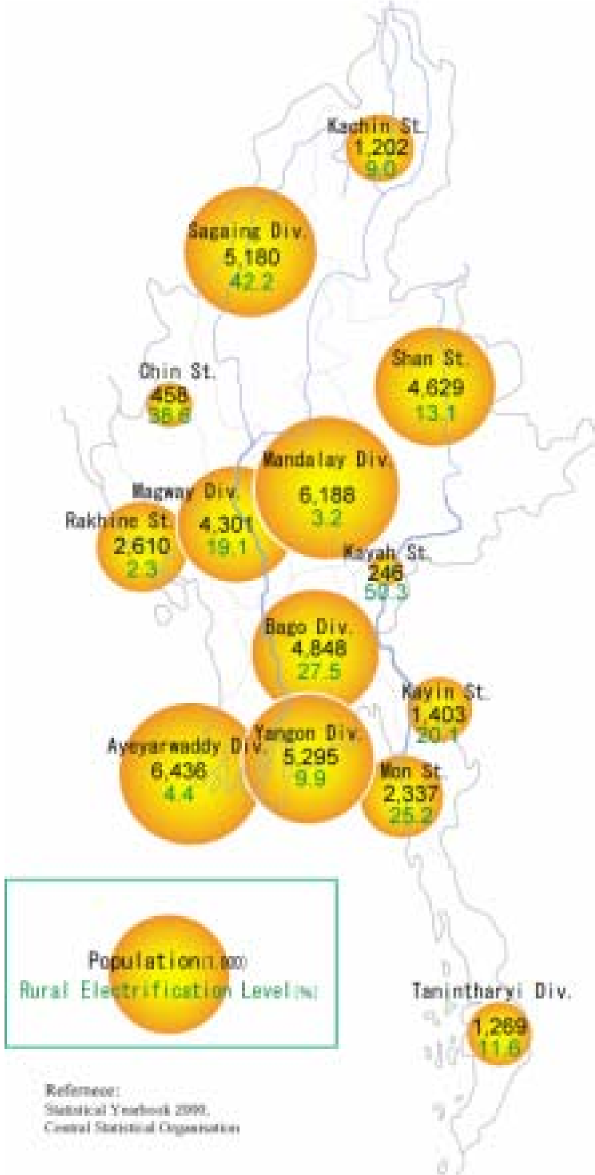


Figure 2 Population and Electrification Level of Myanmar by State

Table 1 Electrification Level in Myanmar

State/Division	No. of District	No. of Township	No. of Village	Poppu-lation	Electrification Level (%)		
					Urban	Rural	Total
Kachin S.	3	18	616	1,202	63.7	9.0	25.0
Kayah S.	2	7	79	246	64.3	50.3	54.1
Kayin S.	3	7	377	1,403	57.6	20.1	24.3
Chin S.	2	9	476	458	92.2	38.6	47.1
Sagaing D.	8	38	1,816	5,180	90.9	42.2	61.4
Tanintharyi D.	3	10	263	1,269	50.3	11.6	31.6
Bago D.	4	28	1,409	4,848	82.1	27.5	46.7
Magway D.	5	25	1,543	4,301	92.5	19.1	36.7
Mandalay D.	7	30	1,567	6,188	65.6	3.2	22.1
Mon S.	2	10	381	2,337	28.8	25.2	27.4
Rakhine S.	5	17	1,041	2,610	41.0	2.3	18.5
Yangon D.	4	45	677	5,295	67.3	9.9	49.9
Shan S.	11	54	1,627	4,629	55.1	13.1	30.5
Ayeyarwady D.	5	26	1,920	6,436	49.7	4.4	8.7
Total	64	324	13,792	46,402	71.6	17.7	37.0

Source:
Number of District and Township: "Myanmar Facts and Figures", Min. of Information (March 2000)
Population in 1997: Statistical Yearbook 2000, Central Statistical Organization (CSO)
Number of Village Tract: "Districts, Townships, Towns, Quarters, Village Tracts and Villages in the States and Divisions", Administration Department, Ministry of Home Affairs
Electrification level: Report of 1997, Household Income and Expenditure Survey, CSO, 1999

The household electrification level at 37% on the national average including urban areas (18% in rural areas) is low compared with other ASEAN countries as may be seen in Table 2.

Table 2 Electrification Level of ASEAN Countries

Items	Myanmar	Thai	Vietnam	Malaysia	Indonesia	The Philippines
Population (1,000)	48,132	58,400	73,790	20,690	193,750	70,270
per capita generation capacity (kW)	0.022	0.295	0.072	0.378	0.084	0.109
Electrification level (%)	37 (18% in rural areas)	89	60	56 (Salawak) 54 (Sabah)	51 (nationwide)	86 (NPC) 56 (co-ops)

Source: Prepared based on "Study of Dispersed Small Hydros, March 1996", Japan Association of Civil Engineers.

(3) Power Grid of MEPE

In Myanmar, a severe power shortage has continued even in the Grid of MEPE (refer to Figure 3 for the network extension in Myanmar). The Grid has a total generating capacity of 1,172 MW, which consists of hydro 360 MW, thermal 216 MW, gas turbine (including combined cycle) 530 MW, and diesel 66 MW. The firm peak capacity of the Grid was 71 MW in 2000/01 while the Grid peak load was at 1,005 MW resulting in a power shortage at 289 MW, which were managed by pending connections of waiting consumers and load shedding.

The energy generated was 5,020 GWh and the energy sold 3,715 GWh in 2000/01. The generation costs were K20.6 billion, which was equivalent to a unit generation cost at K4.10/kWh. The electricity losses amounted to 38% of the electricity generated before 1997/98 and reported to be improved to 24% by 2000/01. Due to the high losses, the unit energy cost at the consumer end became K5.55 per kWh sold in 2000/01.

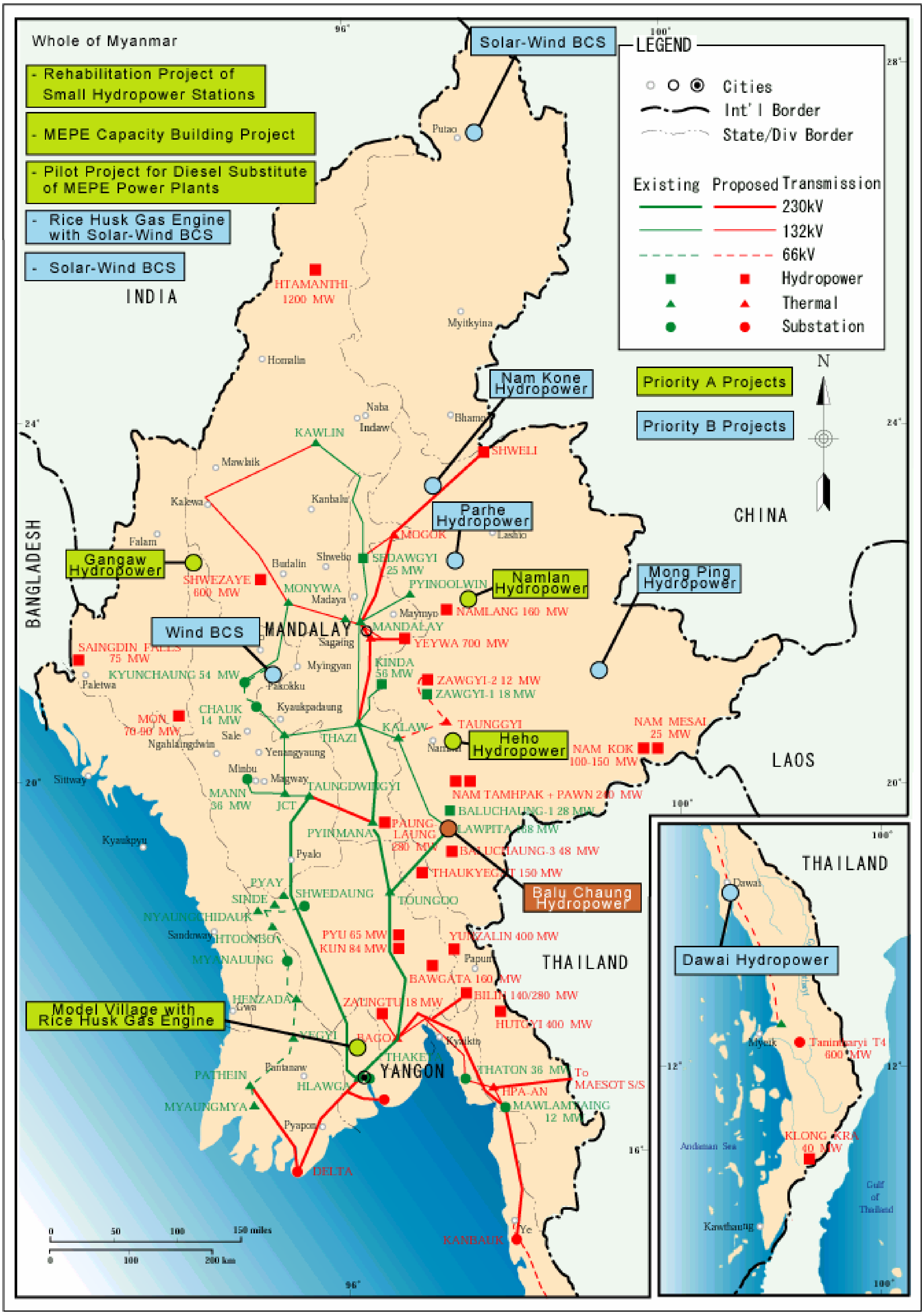
The gas turbine plants generated 63% of the total energy and hydro 18%. The number of MEPE consumers was 1.025 million, the number of townships electrified 323, and the number of village tracts electrified 1,117 as of 2000/01.

The transmission system consists of 230 kV lines (874 miles) and 132 kV lines (1,165 miles) in 2000/01. The distribution lines consist of 66 kV lines (1,045 miles), 33 kV lines (2,193 miles), and 11 kV lines (4,677 miles).

To cope with the sever shortage of the generation capacity in the Grid, the Government has launched a strategic generation expansion plan to implement hydropower projects of 2,000 MW in total installed capacity in five years starting from 2001. In parallel, a transmission expansion plan of the Grid is under study to transmit the power generated to the demand centers in the Grid.

(4) Power Supply Conditions of MEPE Grid

Except for those townships situated inside the large cities, the townships outside large cities and local townships consist of urbanized central part referred to as quarter and surrounding villages. Even in some townships close to Yangon, only the quarters are electrified. In the quarters, load shedding was daily imposed in 2001 for 9 hours a day. Time of the load shedding is changed daily. People can receive power during the evening peak time every other day. The surrounding villages are mostly not electrified though distribution lines may pass by. In order to get power supply from the Grid, villagers are required to raise some fund for installation of transformers and distribution lines. It is said that these villages are not electrified because the villagers cannot raise the required funds. However, the real situation appears that these villages cannot be electrified by extension of distribution lines due to the shortage of the Grid power and line capacity.



Source: Compiled by JICA Study Team

Figure 3 Power Grid of MEPE

Under the present supply-demand conditions, the ongoing large-scale expansion of the generation capacity of the Grid would alleviate the present heavy load shedding problem and would contribute to electrifying the rural areas in and around the Grid.

(5) Present Conditions of Rural Electrification in Remote Areas

Nationwide Township Electrification by MEPE

In 1990s when peace agreements were concluded between SPDC and state governments one after another, SPDC put efforts to electrification of townships of all the states and divisions. As a result of the efforts, all the townships amounting to 323 (324 as of 2003) over the country had been electrified by 1996 at least in the central part of each township. Central urban areas of each township are supplied by a local independent power system of MEPE with diesel generators and/or small hydros. MEPE is operating 456 diesel generators and 30 small hydros for the rural electrification. Diesel generators are operated for 3 hours a day due to the limitation of fuel budget. Since the operating costs of these local power systems cannot be met by operating revenue, the costs are covered by remittance from MEPE Headquarters. Hydropower plants are operating for 24 hours a day. However, since their output drops significantly in the dry season, power is supplied only to a limited area in the dry season and to the full area in the rainy season. Most villages situated surrounding the township centre are not electrified.

Utilization of Battery-Lighting System as Kerosene Lamp Substitute

BCS (Battery Charging Station)-charged battery-lighting systems have been widely (32% of rural households as of 1997) introduced to power 4-8 W fluorescent lamps. According to the interview survey conducted in villages around Yangon, these battery-lighting systems were introduced when kerosene disappeared from the market upon the First Oil Crisis in 1973. Before that kerosene lamps were the main source of lighting at farm households. As a result of the non-availability of kerosene, many BCSs, based on the cheap power of the Grid, started business on a commercial basis in the area adjacent to the Grid. In areas distant from the Grid, BCSs are powered by diesel generators.

Most of the existing BCSs in Myanmar charge batteries by serial connection, which will deteriorate batteries. It is strongly recommended that the batteries be charged by parallel connection as shown in Appendix-8.

In parallel with start of the BCS business, batteries and small fluorescent lamps flooded the market. At that time, smaller scale 8 V batteries which farmers can purchase at a lower price have dominated the market rather than standard 12 V batteries. As a result, 8 V fluorescent lamps also have dominated the market pushing aside the 12 V products. A fluorescent lamp is significantly bright even at 8 W. However, those available in the market are short in lifetime and need frequent replacements. Accordingly, in the households that cannot afford to buy a fluorescent lamp at about $1.00 (K500 in 2001), people use small incandescent bulbs that are less bright but are cheaper and last longer. Battery recycling shops have been in operation on commercial basis. Electrodes are recollected nationwide and recycling manufacturers in Yangon are reproducing recycled electrodes. The cases and connectors are recycled at shops operating in local areas.

These battery-lighting systems may provide valuable lights for dinner and communication among the family. However, such lighting is inadequate for children to read books and may weaken their eyesight.

These battery-lighting systems were a "Kerosene Lamp Substitute" introduced and spread as self-help and self-defense measures against the First Oil Crisis in 1973. The earliest implementation of rural electrification (RE) has been strongly desired nationwide.

RE with Other Power Sources

In addition to the electrification of township centers by MEPE and the battery-lighting on commercial basis, there are many small scale RE as listed below:

- A small diesel generator for self consumption, with some power also fed to neighboring households;
- *Village Hydros* of smaller than 50 kW, with technical assistance by a private sector expert (refer to Appendix-1 for a list);
- 300 W to 1 kW Chinese turbine-generator packages are available in the local market (see Table 32 and Visual Guide for more details);
- Solar Home Systems (SHS): India-made solar PV panels are used in Chin State, some are being used in villages around Yangon;
- Solar-wind BCSs, contributed by NGO and rich donors: there is no example of self-installed BCS or commercial BCS using solar-wind power;
- Rice husk gas engines introduced to power rice-mills: also generate some electric power, which is fed to neighboring households.

(6) Steps and Definition of Electrification

In the MEPE statistics, those households that receive power supply from MEPE through a Watt-hour meter are regarded and counted as the Electrified Households.

It is defined in the Guidelines that electrified households mean those who can receive electricity through distribution lines from MEPE, independent power producer (IPP), village electrification committee (VEC), etc. or directly from self-generators.

The minimum level of RE target is to receive power supply throughout the year for 3 hours a day in the evening time, and in quantity-wise is to be able to use 3 numbers of 20 W fluorescent lamps and one electric appliance, 80 W in total including distribution losses.

Though battery-lighting with 4-8 W fluorescent lamp uses electricity, it is Kerosene Lamp Substitute in the actual level of lighting and is, therefore, not specifically counted as Electrified Households.

1.2 Potential Demand for Electricity in the Rural Areas

(1) Needs of RE Using Renewable Energy

For the reasons described below, RE in Myanmar needs promotion with renewable energy as sources of power represented by small hydros, solar, wind, and biomass:

Since both of the Grid and local independent (isolated) power systems have inadequate power generation capacity, it cannot be expected on the short- to medium-term to implement RE by extension of distribution lines from the Grid or local power systems (the grid extension).

"Securing independence in the energy supply" is the first objective of the national energy policy, and accordingly RE should be promoted using domestic energy resources.

Inland oilfields of Myanmar have been mostly exploited. Although natural gas is exploited at off-shore fields, export will be given top priority in view of the national economy. It is not practical to use domestic natural gas for RE.

There are coal reserves in Myanmar. Implementation of the Tigyit coal power plant (120 MW) was decided in August 2001. There is a plan of Kalewa coal power plant (100 MW). Briquette is produced from coal as firewood substitute in order to conserve forest resources. However, coal power plants are not suitable for small scale power generation for independent RE systems.

It is a big burden to MEPE to secure the fund for purchasing diesel oil for diesel plants that are installed in local independent power systems and amount to 525 units (456 units in operation and 69 units on standby) and 65 MW in total. A total generation of 44 GWh by diesel generators in 2000 needed fuel costing about $1.4 million (K700 million) at an official fuel price of K160/gallon, assuming one gallon of diesel can generate 10 kWh. On the other hand, a total operating revenue of MEPE was $45 million (K22.4 billion) in 2000. A 3.1% of the gross revenue of MEPE was spent for purchasing diesel for RE. The market price of diesel oil is far more expensive than the inter-government price. If it is assumed at K600/gallon, the diesel cost of MEPE for RE would have amounted to $5.3 million (K2.6 billion) or 12% of the total budget of MEPE. Saving and substitute of fuel oil are prime issues of MEPE as well as of the Nation's economy.

As the remaining domestic energy resources, only renewable energy including small hydro (<10 MW) are available for RE in Myanmar, putting aside medium to large scale hydropower (>10 MW). Isolated power systems using renewable energy are suitable for RE in such remote areas where demand density is low. It will not require a large-scale investment such as for large scale generation projects to feed the Grid. Although the capital efficiency is relatively low, the capital requirements of individual RE projects becomes smaller. In addition, RE schemes using renewable energy do not require hard currency to import fuel and its costs for O&M are relatively small. It will contribute to sustainable management of the RE schemes. Promotion of RE using renewable energy will also contribute to saving fuel oil and reducing CO_2 emission and greenhouse effect.

(2) Power Demand Forecast for RE

According to the village social survey conducted by interviewing 1,348 households under the Study in May-June 2001 (VSS2001), the priority in the household basic needs is ranked at 1) health, 2) electricity, 3) money, 4) education, and 5) food. It is notable that the electricity is ranked higher than money, education, and food.

Electricity demand was forecast by grouping consumers into four types, that is, household, public, business, and industry.

The electricity demand P_D of a village of interest is forecast by the following equations:

$$P_D = P_H + P_P + P_B + P_I \quad \cdots\cdots(1)$$

$$P_x = n_x W_x C_x A_x / 1{,}000 \quad \cdots\cdots(2)$$

where,
- P_x : Electricity demand of x sector in kW, where suffix H denotes for household, P for public, B for business, and I for industry
- n_x : number of consumers of x sector;
- W_x : Unit consumption of x sector in W
- C_x : Ratio of concurrent use of x sector in the peak time
- A_x : Affordability ratio of x sector.

Unit consumption of each sector was assumed based on the field survey as presented in Appendix-6.

Household Demand upon Electrification (First Step)

It is assumed for RE schemes of MEPE that each household will have three lights in totalling 90 W and one small radio of 10 W. In addition, 50% of the households would have one TV of 60 W. These will be 130 W in total. Taking into consideration the ratio of concurrent use, the net demand was estimated at 118 W per household (Appendix-6).

Household Demand with Rice Cooker (Second Step)

It is assumed that 15% of the households will have 600 W electric cookers within several years after electrification (Second Step). According to VSS2001, villagers have a preference for “rice cooker” as a future appliance that they would buy as a second priority after lighting. With the rice cooker, the net household demand will increase to 163 W. However, the preference may be resulted from the present low level of power tariff and the actual introduction of rice cooker would be dependent on the future tariff level of MEPE.

Household Affordability of Electricity

Some households may not be able to access electricity due to their low income. Field survey suggested that the borderline may be around K100,000 a year. The database of household income obtained through VSS2001 gave the percentage of the affordable households that were defined to have higher income than K100,000 as shown in Table 3. About 88% of the households on an average would enjoy receiving power upon the electrification of their village while 12% could not afford it.

Table 3 Household Affordability of Electricity

(%)

Description	Shan South	Shan North	Kachin	Total
Non-electrified	86	82	93	87
Electrified	89	93	94	92
Average	87	84	93	88

Source: VSS2001

With the unit demand as estimated above, the order of electricity demand for RE is forecast as shown in Table 4 by State. The gross demand for new lighting is in an order of 690-950 MW, which is in the similar order to the supply scale of the Grid in 2001.

Table 4 Electricity Demand for Rural Electrification by State

No.	State/Division	Population 1983 Census			Population in 1997		Rural House-holds	Power Demand	
		Urban	Rural	Total	Total	Rural		Upon RE	After several years
		1,000	1,000	1,000	1,000	1,000	1,000	MW	MW
		1	2	3	4	5	6	7	8
1	Kachin State	181	638	819	1,202	936	156	19	25
2	Kayah State	42	118	160	246	181	30	4	5
3	Kayin State	105	528	633	1,403	1,170	195	23	31
4	Chin State	54	315	369	458	391	65	8	10
5	Sagaing Division	530	3,295	3,825	5,180	4,462	744	89	119
6	Tanintharyi Division	216	698	914	1,269	969	162	19	26
7	Bago Division	740	3,060	3,800	4,848	3,904	651	78	104
8	Magway Division	493	2,750	3,243	4,301	3,647	608	73	97
9	Mandalay Division	1,214	3,364	4,578	6,188	4,547	758	91	121
10	Mon State	473	1,207	1,680	2,337	1,679	280	34	45
11	Rakhine State	304	1,742	2,046	2,610	2,222	370	44	59
12	Yangon Division	2,706	1,260	3,966	5,295	1,682	280	34	45
13	Shan State	658	2,432	3,090	4,629	3,643	607	73	97
14	Ayeyarwady Divisior	742	4,252	4,994	6,436	5,480	913	110	146
	Union Total	8,458	25,659	34,117	46,402	34,913	5,819	699	930

Source: Forecast of JICA Study Team, with
population data by Statistical Yearbook 2000, Central Statistical Organization, Yangon, Myanmar, 2000, Ministry of National Planning and Economic Development

Note: (1) Average family size was assumed at 6.
(2) Rural population 1997 was assumed based on total population in 1997 and rural population ratio in 1983.
(3) Column 7 shows demand just after electrification when unit demand is forecast at 120 W per household.
(4) Colume 8 shows demand after several years when electric appliances other than lights are introduced to increase the average unit demand to 160 W per household.

1.3 Willingness and Ability to Pay

Willingness to Pay (WTP) for RE is related to two payments; the initial connection fee to recover initial capital costs and monthly payments to recover monthly O&M expenses.

(1) WTP

Table 5 presents average WTP and actual payments for electricity.

Table 5 Willingness to Pay and Actual Payments

(Unit: Kyat)

Items	Payments	Non-electrified Villages	Electrified Villages	Total
WTP	Initial	9,100	15,500	10,400
	Monthly	520	750	570
Actual payments	Initial	-	23,500	-
	Monthly	-	370	-

Source: VSS2001

The average WTP for initial connection fee was K9,100 in the non-electrified villages and K15,500 in the electrified villages with overall average at K10,400. The actual payment was K23,500 and exceeded WTP at K15,500. However, the people in the electrified villages appreciate these payments as appropriate. WTP for monthly payments was K570 per month on an overall average.

(2) Ability to Pay (ATP)

The WTPs for the initial connection fee and one year monthly payments are presented in Table 6 together with household income, expenditure, and saving for both the non-electrified and electrified villages.

Table 6 Ability to Pay

(Unit: Kyat)

Items	Non-electrified Villages	Electrified Villages
WTP for initial connection fee plus 12 monthly payments for the first one year	15,300	24,400
Annual income	266,000	380,000
Annual expenditure	227,000	310,000
Saving	39,000	70,000

Source: VSS2001

The saving is much greater than the WTPs. ATP in the surveyed area is about US80 (K39,000) in the non-electrified villages and $140 (K 70,000) in the electrified villages.

1.4 Prospects for Community Participation

Not as *People Participation* which is the world trend sounding soft and sometimes mistreated as accessories of development projects, small scale RE in Myanmar can make progress only if it is implemented under the leadership of the villagers themselves. Those RE schemes by the grid extension and construction of small hydropowers will be continued by MEPE in the future also. However, if villagers depend only on the RE schemes by MEPE, it will become necessary for the villagers to wait until the Grid and local independent power systems acquire sufficient generation capacity, that is, until such time when the present load shedding will become unnecessary. Even with an optimistic assumption that RE level be improved by 2% per year, it would take more than 40 year period for the transmission and distribution networks to reach the majority of the local towns and villages country-wide.

Accordingly, it will be a prerequisite for the villagers and VECs to implement RE schemes on a self-help basis in parallel with those RE schemes directly implemented by MEPE. There may be the following options for RE schemes by the villagers:

- Installation and management of rural electrification schemes by the villagers (VEC) using:
    - Pico hydro (300 W to 1 kW);
    - *Village Hydro* (<50 kW) with financial and technical assistance from external sources like private sector and NGOs;
    - rice husk (biomass) gas engine by pyrolysis (thermal decomposition);
    - Solar-wind BCS with financial and technical assistance from external sources like NGOs;
- O&M of small hydropower stations and management of independent power systems being entrusted by MEPE;
- Advice from foregoing electrified villages to rural electrification schemes of non-electrified villages;
- Contribution to the RE Fund from the monthly installments of VECs which implemented its rural electrification scheme with financial support from such Fund.

According to VSS2001, the majority (57.8%) of the villagers out of the 1,348 households showed their positive will to participate, 33.2% neutral, and 9% negative. Of the positive reply, their participation ways are 1) as a member of VEC at 32.4%, 2) as money collector at 14. 9%, 3) as maintenance team member at 14.3%, 4) by paying tariff without delay at 14.0%, and so on. The negative opinion showed the reason as 1) too busy at 43.2%, 2) too old at 33.1%, 3) lack of males in the household at 13.6%, and 4) illiteracy at 8.5%.

2. Feasibility of RE with Renewable Energy

2.1 Overview of Use of Renewable Energy in Myanmar

The Guidelines deal with four forms of renewable energy, that is, small hydro, solar, wind, and biomass as the energy sources available and suitable for RE in Myanmar. As of the renewable energy sources, there are also geothermal power, biogas power, Refuse Derived Fuel (RDF) power, wave power, solar heat power, and so forth. However, these are not dealt with in the Guidelines for the reasons as briefed in Appendix-2.

The four forms of renewable energy are suitable as the energy sources of independent power systems for RE. Table 7 presents an overview of the features of these.

Table 7 Overview of Features of Renewable Energy

No.	Energy Source	Features
1.	**Small Hydropower**	● There are various scales: small hydro <10,000 kW, mini hydro <1,000 kW, micro hydro <100 kW, Pico hydro <1 kW. In the Guidelines, *Village Hydros* are defined as those smaller than 50 kW. ● Depending on the scale, it can feed both Grid and local independent power systems; full RE of one village; small scale electrification of one to 10s households. ● Although the output drops in the dry season, power generation can be continued throughout the year except for western coastal basins in the Rakhine State, Tanintharyi and CDZ. ● Since hydro-potential depends on the site, it will be required to study both potential and demand of target village. In the case of small scale generation of isolated village in particular, if the potential is high enough, then the RE demand of the target village can be fully met. ● There are 30 small and mini-hydros (>100 kW) owned and operated by MEPE. More than 30 numbers of *Village Hydros* mostly smaller than 20 kW with exceptions of 50 kW and 75 kW were installed by private sector experts. There are also a significant number of Pico hydros (<1 kW) installed and operated by villagers. ● Myanmar has own technologies for small hydros: · Technologies of MEPE for planning, design, construction, O&M, repair, and know-how for tariff collection and electricity business management. · Manufacturing technologies of private sector for small turbines, penstock pipes, transformers, concrete poles for distribution lines. · Technologies of private sector for small hydro and know-how of VECs for management of electricity business.

2.	**Solar Power**	● Although the energy density is low compared to the other forms of energy, solar power can be applied to RE with BCS or SHS. ● It can generate only during daytime, and the output drops to about a half under clouds in the rainy season. ● Samples in Myanmar are observed as solar pumping system to pump up groundwater and as a cold storage system of vaccine. ● There are existing related technologies such as BCS and recycling of batteries. ● Necessary number of BCS can be installed depending on the village scale. ● The initial capital costs is high and can hardly be installed without external financial support, except for SHS to high income households.
3.	**Wind Power**	● The output changes from time to time. ● Detailed survey of wind potential is indispensable for planning of large scale scheme in particular. ● Wind power potential in Myanmar is in general low. However, there is certain wind potential (average speed lower than 3 m/s) for small sized wind turbines in the coastal areas of western and peninsular regions, wind corridor inland and western edge of the Shan Plateau. ● Number of installations in Myanmar is limited. ● The world trend is to achieve diversification of energy sources by operating large wind schemes being connected to a grid, expansion of a share of clean energy, and public relations effect. ● It would be suitable to use small wind power in the local wind corridor as energy source of BCS for RE in Myanmar.
4.	**Biomass Power**	● The biomass utilized in Myanmar includes firewood and charcoal, aged rubber trees, rice husk, bagasse (waste of sugar cane after squeezing), wood chips and sawdust from sawmills, cob and stalks of maize, been stalks, reed, cow-dung, etc. Of these, rice husk, bagasse, and wood chips are used also for power generation. ● Bagasse is discharged only for 5 harvesting months of sugar cane and is used as sources of power and heat of sugar-mills. Bagasse has a high moisture content exceeding 50% and is, therefore, inappropriate for gasification by pyrolysis and for storage for the use in non-harvesting months. ● In Myanmar there are various demands for the rice husks from brick factories, spirits distilleries, restaurants, homes, etc. Rice husks are commodity being traded in Myanmar. ● The total installed capacity of existing power generating units (steam turbine) attached to 13 large scale rice-mills is 4,125 kW in total. ● The existing power generating units attached to 17 sugar-mills (steam turbine) have a total installed capacity of 33 MW. - to be continued -

		• There is existing local technology for biomass gasification by pyrolysis and power generation using diesel engines. • If the fuel (rice husk, wood chips) supply is secured, the generation scale could be adjusted to meet the demand up to about 50 kW. • The issue is collection and transportation of the biomass. → It is important to locate the biomass plant beside the fuel sources, that is, rice-mill or sawmill.

Source: JICA Study Team

Table 8 presents situation of use of these renewable energy in Myanmar and applicability to rural electrification. The upper rows are for large scale plants for Grid, and the lower rows for renewable energy sources for RE.

It has been planned to implement generation projects of 2,000 MW in total capacity in the Five Year Plan (2001-2005) as generation sources for the Grid. Once these started power generation one by one, the load shedding of the Grid would be alleviated and solved and the electrification of the villages around the Grid would be materialized by extending distribution lines.

As shown in the lower rows of Table 8, there are significant differences in the quality of electricity generated by the four forms of renewable energy. The hydropower greater than 50 kW can generate high quality power comparable to those of the Grid and can supply everyday. In particular small hydros of greater than 100 kW scale can supply for lighting, electric appliances like radio, TV, and rice cooker, and even daytime demand for cottage industry. In the case of BCS powered by solar PV panel or wind turbine, it will be limited to use on lighting, radio, and TV even with the use of large batteries. In the case of rice husk gas engine, it can supply to cookers, water supply pumps, etc. However, the existing husk engine system available in Myanmar should limit the use for lighting, TV, and the like.

Table 8 Applicability of Renewable Energy to RE

Form of Energy	Potential and Features in Myanmar	Issues	Advantages	Power Scale	Min. RE for Lighting	Full RE with 24 hr Supply	Cost Level ($/kW)	Overall Judgement of Applicability to RE	
								Rank	Remarks
Large Scale Power Sources of National Power Grid									
Hydropower	Potential at 100,000 MW	Shortage of finance.	Stable supply of cheap and quality power in large scale.	10-1,000 MW	OK	OK	1,000-3,000	**C**	Not applicable to RE at present. Upon significant reinforcement of the Grid generation capacity, these will enable full scale RE around Grid by extending distribution lines.
Thermal power	D/Gs in local isolated systems supplying only 3	Shortage in supply of fuel and spare parts.	Short lead time and small capital cost.	0.1-300 MW	OK	OK	200-1,500	**C**	
Large scale wind power solely for supply to Grid	Potential unstable & limited to western & peninsular coasts.	Potential cannot be developed because Grid has not been extended to coasts.	Clean energy.	50-1,000 kW	OK	n.a.	1,000-3,000	**C**	
Distribution lines extended from Grid	RE by Grid extension cannot be expected at present.	Shortage of generating capacity in the Grid.	Stable supply of cheap and quality power owing to the scale merit of Grid.	-	OK	OK	8,000/km	**C**	
Small Scale Local Sources for Rural Electrification									
Small and mini-hydro	Prospective in areas like Shan Plateau. Existing at 30	Arrangement of initial capital costs. O&M by VEC.	Stable supply of cheap & quality power in signi. scale.	< 10,000 kW	OK	OK	1,500-4,000	**A**	Preferred in view of quality and sustainability.
Village Hydro (micro hydro, < 50 kW)	Suitable for village electrification by VEC with support from NGO.	Arrangement of fund & experts for development by VEC. Capacity building.	Low costs, max. use of local resources, stable supply of quality power.	< 50 kW	OK	OK	600-2,000	**A**	
Pico hydro	Turbine-generator set readily available in market. Suitable to RE of 1 to 20 households.	Villagers' knowledge on Pico hydro. Load management and output control.	Short lead time and small cost.	< 1 kW	OK	n.a.	100-300	**A**	Preferred in view of quick installation & low cost.
Solar BCS (Battery Charging Station)	Many samples of BCS exist.	- Low energy density - Fluctuation in output - Need of battery - Wind potential differs from site to site - High costs	Quick installation even in remote areas.	0.1-3 kWp	OK	n.a.	7,000	**B**	Preferred in view of quick installation and easy maintenance provided that external financial assistance is available.
Solar-wind hybrid BCS	Two installed by NGO.		Wind power in rainy season & solar power in dry season.	0.5-3 kWp	OK	n.a.	7,000	**B**	
Solar/wind pumping, etc.	Prospective for water pumping in CDZ and cold chain for vaccine		Quick installation of low maintenance power system in isolated areas. No battery.	0.17-1.2 kWp	OK	n.a.	7,000	**B**	
SHS (Solar Home System)	Potential high in CDZ.		No need of going to and charging battery at BCS.	0.05-3.0 kWp	OK	n.a.	7,000	**B**	Applicable only to rich households that can afford costs.
Large scale solar power plant for RE	Potential high in CDZ.	- High capital costs	No fuel and less maintenance	50-1,000 kWp	OK	OK	4,600-7,000	**C**	Not recommendable at present due to high costs.
Biomass steam turbine	Suitable for large scale rice-mills and sugarmills.	Low heat efficiency. Supply of bagasse is very seasonal.	Use of waste as source of factory power	200s-20,000s kW	OK	OK only during season	1,800-5,000	**C**	Not recommendable due to high costs and complicated system.
Biomass gas engine	Max. use of local technology and resources. Star for RE in paddy-cultivating regions.	Arrangement of initial costs and personnel for O&M.	Quick installation and stable supply of cheap power for lighting, TV, etc.	10-50 kW	OK	5-20 hr/day	400-1,000	**A**	Preferred in view of low costs & quick installation.

Source: JICA Study Team

2.2 Feasibility of Small Hydropower

(1) Feasibility of Small Hydropower (>50 kW) by MEPE

Small Hydropower (>50 kW) to be implemented by MEPE will implement full scale RE with 24 hour supply. It is possible to supply also to daytime demand from cottage industry.

Although kW construction costs of independent small hydros would exceed those of middle to large scale hydros, the economic feasibility of the small hydros will improve if such costs can be avoided that will be required for construction of long transmission lines for an alternative electrification scheme by the grid extension. For example, a village having a lighting demand of 100 kW may be electrified either by extending a transmission line from the Grid or by installing an independent Village Hydros nearby the village if such potential exists. The grid extension would cost, for example, $4,000/kW (assuming unit cost and line length as $8,000/km x 50 km / 100 kW) while the small hydros would cost $1,500-4,000/kW being lower compared to the grid extension.

Compared to the middle to large scale hydros, the small hydro has such effect as splitting the financial requirement into many and small ones.

The small hydro is suitable as power source of the local independent power systems like in Shan Plateau where economic hydro potentials widely exist.

The hydropower could not be used for independent power systems in Rakhine State, Tanintharyi division, and CDZ since many of the rivers there except for spring-fed creeks are not perennial and dry up in the dry season.

The main issue is to secure the necessary fund for initial investment to the implementation of these small but many hydro schemes.

Another issue may be to make MEPE organization slim and efficient through entrusting O&M and management of small RE schemes including tariff collection to VECs.

(2) Feasibility of Village Hydro (<50 kW) by VECs

Village Hydros (<50 kW) and Pico hydro (<1 kW) are also very suitable for electrification of small villages or household groups nearby the potential sites. Employment of local technologies and contribution by villagers in construction works has been in practice.

A private sector expert in Taunggyi has installed 33 *Village Hydros* in Shan State in the past 20 years as listed in Appendix-1. Generating equipment is mostly manufactured locally except for generator. Governor is not provided and the turbine output is manually controlled by guidevane and intake gate. Civil works, building works, and distribution line works are mostly executed by villagers participation. As the results, the fund requirement is as low as $600 per kW capacity of generator.

Pico hydro using a China made turbine-generator module is also highly feasible where a perennial creek with a head of about one meter is available. The unit cost is in the range of $100-300 per kW of assumed output.

The issues are capacity building for planning, implementation, and management of these hydro schemes, arrangement of initial capital costs, and procurement of turbines and generators.

2.3 Feasibility of Solar Power

(1) Applicability to RE in Remote Areas and Feasibility of Solar BCS

A solar Battery Charging System (BCS) requires PV arrays and battery charger. No stationary batteries are required in BCS. Batteries are charged by PV power in parallel connection from the charge controller. Batteries are usually owned personally and users bring their batteries to BCS for recharging every 4-5 days. A battery of the BCS system is like a mobile energy container.

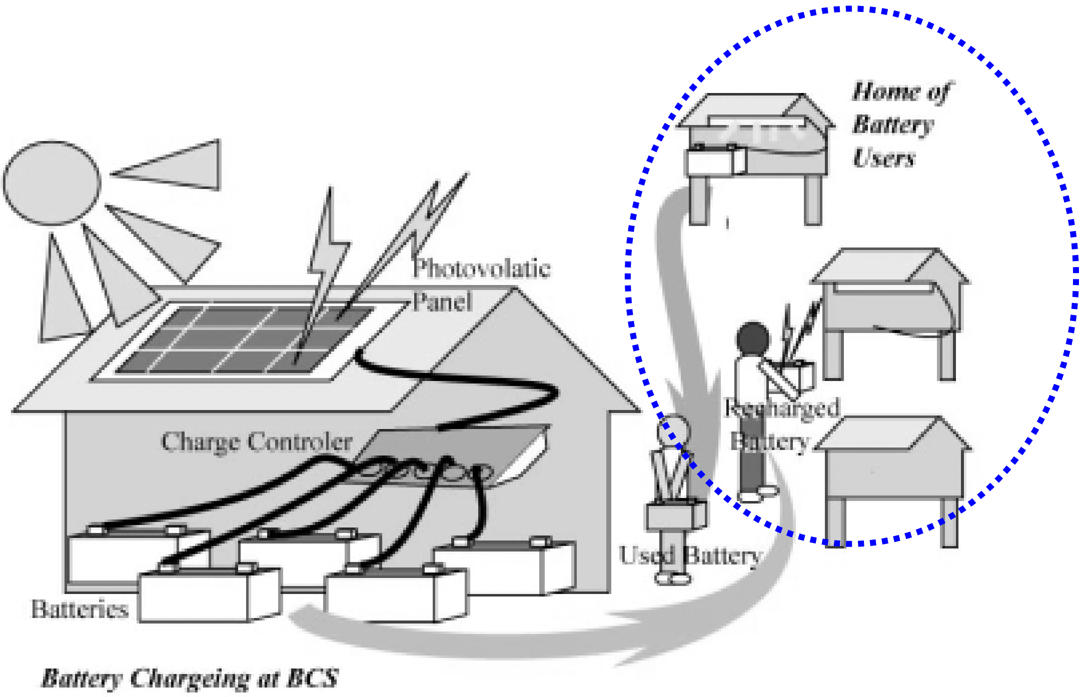


Figure 4 Concept of Solar BCS

Solar BCS is featured by:

- Short lead time from decision to starting operation;
- Easy in transportation and simple in installation works;
- Almost maintenance-free;
- Suitable for electrification of remote areas where the other forms of renewable energy are not practically available;
- An NGO in Myanmar is promoting *community center electrification* which provides Community Hall, often Monastery, with several 20 W fluorescent

lamps with library so that school children can get together here for book reading and studying after having dinner at home;

- The *community center electrification* should be of SHS type and should complement the household electrification by BCS; and
- The largest issue is the cost of solar PV panels of which international price level is at $4.0/Wp and it would increase to about $7.0/Wp including auxiliary equipment. External financial support will be indispensable to meet the costs. However, even when external financial support is provided, costs of consumables such as batteries and lights for home use should be borne by individual households to secure the sustainability.

(2) Applicability to RE in Remote Areas and Feasibility of Solar SHS

Solar Home Systems (SHS) are PV systems and vary from a small system that powers a simple lighting in one household to a large system supplying power to many households by wires. SHS is a 12 V direct current (DC) stand-alone system which uses PV to electrify rural households. SHS is composed of a PV module, a battery, a charge controller, wiring, fluorescent lights, and outlets for other appliances as shown in Figure 5. The capacity of SHS can be decided in accordance with user's demand and ability to pay.

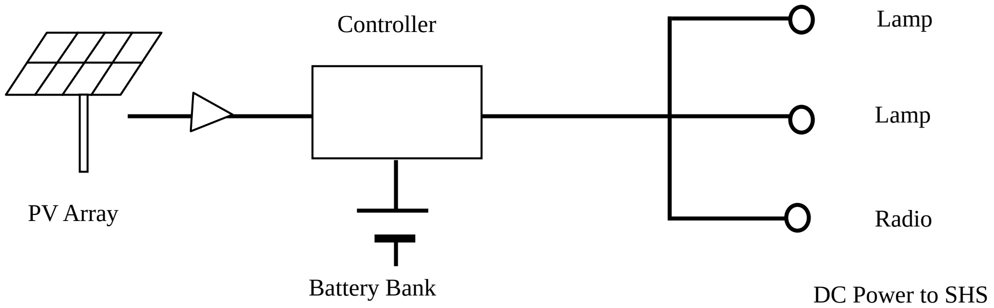


Figure 5 Configuration of SHS

In the case of SHS that installs a small PV panel and battery charging system to individual household, it is not required to carry battery up to BCS for charging every 4-5 days and can improve the level of electrification using a larger battery. Power can be supplied even on rainy days from the battery unless heavy rainy days continue.

The issue is only high income households can introduce costly SHS.

According to a past example in a foreign county, if SHS is introduced to all the households in a village as a whole, it was reported that system maintenance, including training of load management, and battery charging as well as inspection became difficult since the number of charging systems amounted to many and were distributed all over the village. Replacement of battery was required almost every year. However, some households could not raise money for battery replacement depending on their income level, and the PV panel and charging controller were left unused. In the case of rural electrification except for individual introduction of SHS and *community center electrification* by SHS, it will be more practical to adopt BCS system that has been in use nationwide.

(3) Applicability to RE in Remote Area and Feasibility of Solar Power Plant

A solar power plant of 10s kW to MW scale with distribution lines is costly and would not be suitable for RE in Myanmar where cheaper alternative energy sources such as *Village Hydros* and biomass are available, unless external financial support is available.

2.4 Feasibility of Wind Power

Applicability to RE and Feasibility of Wind BCS

Since the wind speed has a wide range of seasonal variation in Myanmar, a wind BCS cannot charge batteries throughout the year. As a general pattern in Myanmar, solar power decreases to about a half in the rainy season, while wind power increases in the rainy season. There is a possibility that solar and wind power can compliment each other to form a hybrid system.

Since the local technology is yet at testing stage of a pilot scheme, the equipment will have to be imported.

The wind power potential depends on the site like in hydro. It will be required for the villagers first to judge the wind potential for rural electrification in accordance with the Guidelines. After receiving a proposal and request from villagers, MEPE Township Engineer or private sector expert need to assess the wind potential.

The issues are assessment of wind power potential and raising of the initial capital costs.

2.5 Feasibility of Biomass Power

(1) Feasibility of RE by VEC with Rice Husk Gas Engine

RE by rice husk gas engine is at a cost level that the villagers could marginally afford to introduce the system at their own costs. However, one time payment of all the capital costs is almost impossible for the villagers and some short-term loan that enables repayment by installment will be essential.

The lead time from the planning to commencement of the power supply is as short as several months.

The net output of engine-generator ranges from about 10 to 50 kW. It can supply lighting power to a village scale of 100 to 500 households which cover most of the village scales in Myanmar. It could be installed also in a village smaller than 100 households, although unit cost per household would increase.

Since the technology involved is local and the gasifier and engine generator can be repaired by local engineers, the sustainability is high.

It can supply power for 5 to 20 hours a day depending on the demand, subject to the supply of rice husk and daily maintenance works.

There would be few institutional issues since the husk engine can be installed for a single purpose of RE, being different from biomass fired steam turbines (power generating unit, PGU) attached to large scale rice-mills and sugar-mills as their source of power and heat.

The greatest issue is the securing of the supply of rice husk. There may be almost no extra rice husk at village-based small rice-mills situated in areas where rice husk demand for cooking is high like in villages around Yangon. Rice husk is used also for poultry (as flooring materials) and fuel for burning bricks, distilling spirits, and for drying vermicelli and agricultural products. Rice husk is traded at K20-35 per basket as of September 2001. In some places it is hard to get rice husk even at K35/basket. The price of rice husk varies seasonally with peak in September and October when there is little demand for rice milling. The rice husk price of K35 corresponds to a kWh fuel cost at US cent 2.5 (= K35 / 5 kg x 2.5 kg/kWh / K700/$), which would exceed ATP. The first step of the planning of rural electrification with husk gas engine should be to survey and judge if rice husk can be obtained in the necessary amounts and at affordable costs.

In the paddy cultivating region, the rice for self consumption of the villagers is milled at a small scale rice-mill of mostly 2.5 tonnes/day and sometimes 10-15 tonnes/day. Accordingly rice husk corresponding to the rice for self consumption will be discharged from the village rice-mills. Theoretically, the amount of rice husk, which will be discharged for milling of the rice for self consumption at a unit rate of 130 kg per capita per year, would enable power supply of about 3.5 hours a day (refer to Appendix-4). If rice husk is used as a source of power for the rice-mill itself, about one half of the rice husk produced will be consumed for milling. The other half would be available for power generation and will enable power supply for 1.7 hours a day.

Also in semi-urbanized area, if there is a rice-mill operating and discharging excess rice husk, electrification with rice husk could be implemented. Middle scale rice-mills often have an agreement with a brick or spirits maker for supply of the entire rice husk discharged. It will be essential to check the availability of the husk from the rice-mills nearby the village of interest.

Since specific weight of rice husk is as low as 0.1, rice husk is voluminous. Its transportation is like carrying air and will be costly to carry necessary weight of the husk. The principle is to install the rice husk gas engine beside a rice-mill.

The other issues are temporary arrangement (short-term loan) of initial capital costs, employment of experienced mechanics for daily O&M, and the fact there is only one manufacturer (MIC) in Myanmar.

(2) Feasibility of Wood Chip Gas Engine

One set of wood chip gas engine generator of MIC is operating at a mine in Kachin State. As far as wood chips are available in sufficient quantity and at affordable price, the wood chip gas engine is promising.

A field test of sawdust engine of 300 kW in net output is ongoing in Japan to prove the stable power output and durability under long-term continuous operation meeting the strict environmental regulations.

Wood chip gas engine discharges little ash compared to rice husk gas engine.

The biomass (both rice husk and wood chip) gas engine has potential to replace some of the 456 diesel generators installed and operated by MEPE for RE of local townships nationwide.

(3) Feasibility of Biomass Steam Turbine

Biomass combustion boilers and steam turbines are used as source of power and heat of the large scale rice-mills and sugar-mills of MAPT. Since bagasse is available only for 5 months a year, it is not suitable as source of power for RE.

If it is planned to supply excess power of husk/bagasse generators, which are installed and operated as power source of large scale rice-mills and sugar-mills, to electrification of villages nearby, supply responsibility would be an issue when the mills stop operation for various reasons.

It will be practical for these generators to sell excess power to the Grid through institutional arrangement of IPP system. However, unless the MEPE's power tariff level is revised to reflect actual costs, no Power Purchase Agreement (PPA) from IPP would be concluded.

2.6 Existing Relevant Renewable Energy Installations

The existing relevant installations of RE schemes using renewable energy are summarized in Table 9.

Table 9 Existing Relevant Renewable Energy Installations for RE and Issues

Source of Power	Existing Nos.	Existing Capacity	Owner	Financial Support	Technical Assistance	Issues
Small hydro (<10MW)	11	34.04 MW	MEPE	MEPE	MEPE	Sedimentation, rehabilitation of turbine
Mini hydro (<1MW)	17 (16 of MEPE)	5.23 MW	MEPE, gold mine	MEPE	MEPE	- ditto -
Micro hydro (<100kW)	29 (2 of MEPE)	578.5 kW	MEPE, VEC	Grassroots grant, credit from NGO	MEPE	Rehabilitation, raising initial capital costs
Pico hydro (<1 kW)	6 + many individual	35 kW + many individual	6 of VEC + many indi-vidual	Grassroots grant		Improvement of the way of installation and wiring, output/load management
Rice husk gas engine	109 till 2000, 52 + 21 in 2001/02	8,280 HP (power for rice-mills)	VEC	DPDC	MEPE, MIC	Securing supply of rice husk, arrangement of initial capital costs, consensus on the quality of distribution lines, and public relations
Wood chip gas engine	1	-	Mine	Mine	MIC	Securing supply of wood chip
Solar BCS	One set each in Sagaing, Magwe, Ayeyawady, Mandalay	1,500 Wp 500 Wp 2,560 Wp 400 Wp	VEC, MOF, MOR	UNDP, Donor from Japan	UNDP, NGO	Arrangement of initial capital costs, counter-measures against over charging and over discharging.
Solar-wind hybrid BCS	2	n.a.	Primary school	NGO	NGO	- ditto -
SHS incl. solar pump & vaccine refrigerator	Rakine: 2, Kichin: 1, Sagaing: many, Magwe: many, Ayeyawady, Mandalay	62 kWp + individual	MOH, MOA, individu-al, etc.	Individual (K70,000-K95,000 in 2000)	NGO	Arrangement of initial capital costs up to installation of SHS (Indian-made PV panel)
Husk PGU of rice-mills	13	4,125 kW	MAPT	ADB, OECF, GER	-	One unit out of order.
Bagasse PGU of sugar-mills	17	33,000 kW	MAPT	-	Japan, Netherlands, China, Thailand, Czecho	Some need additional firewood, some have excess bagasse, some have machine problem

Source: Hearing by JICA Study Team

2.7 Availability of Construction Resources in Local Market

(1) Consultants, Manufacturers, Suppliers, etc.

A list of some consultants, manufacturers, suppliers, etc. operating in the local markets are presented in Appendix-13 for reference.

There are surveying companies who own GPS and Total Station.

There are professionals and companies who can undertake geological investigations and construction material survey. However, laboratory tests of construction materials may be made at the MEPE Laboratory or Irrigation Technology Center (ITC) of the Irrigation Department (ID).

There are a few consultants and NGOs in the field of planning, design, and implementation of Village Hydro (<50 kW).

An NGO Karamojia International, Japan provided two sets of solar-wind hybrid BCS systems.

There are manufacturers of gates, trashracks, penstock pipes, transformers, concrete poles for distribution lines.

As for the hydraulic turbines, only micro turbines (<50 kW) have been manufactured by Sein Pann Industrial Production Co-op Ltd., Mandalay. Rural Development & Hydroelectric Implementation Group, Taunggyi has manufactured and installed 33 *Village Hydros* as listed in Appendix-1.

Rice husk gasifier and engine generator sets are manufactured by Myanmar Inventors Cooperative Ltd. (MIC), Yangon.

Construction materials such as cement, reinforcing bar, fuel, etc. can be procured in the local markets or imported through suppliers.

Equipment and materials for switchgears and distribution lines can be procured through suppliers.

(2) Construction Equipment

The construction equipment listed below are available on rental basis in the market:

- Bulldozer of 4 tonne to 25 tonne class
- Wheel loader of 1.7 m3 to 2.1 m3
- Dump truck of 10 tonne to 15 tonne
- Trailer of 30 tonne
- Truck of 2 tonne to 6.5 tonne
- Truck of 4 tonne with crane 2.9 tonne
- Truck crane of 20 tonne
- Motor grader of W 3.1m to 3.7 m
- Road roller of 12 tonne
- Vibrating roller of 12 tonne

- Concrete truck mixer of 6.0 m3
- Water tank truck of 1,000 to 1,600 US gallons
- Welding machine of 300 A
- Rebar cutting and bending machines
- Portable concrete mixer of 0.35 m3
- Air compressor of 7.5 m3/min
- Submersible pump of 4 to 6 inches
- Electric concrete vibrator of 32 mm
- Concrete bucket of 0.5 m3
- Diesel engine generator of 10 to 75 kVA
- The general terms and conditions for the rental of these equipment are:
- Rental cost includes operators, maintenance & lubricant.
- Working hour per day is 8 hrs. Pro-rata rate may be applied for overtime.
- Diesel fuel is to be provided by lessee.
- Mobilization and demobilization are on lessee's account.
- Food and accommodation for supervisor, operator and junior mechanics are to be provided at site by lessee.

(3) Construction Materials

The construction materials listed below are available in the market:

- Portland cement
- Sand, crushed stone as concrete aggregates
- Concrete pole for power distribution lines
- Timber of Teak, Pyinkadoe (hardwood), and Inn-Kanyin (general use)
- Plywood of 2.7 mm, 5.5 mm, and 9 mm in thickness
- Deformed rebar 10-25 mm
- H-beam, I-beam, L angle, C-channel, checkered plate, wire mesh, welding rod, chain block
- Materials for electrical works
- Materials for lighting

(4) Transportation

The transportation cost from Yangon to Mandalay was in an order of Ks. 8,000 per tonne in September 2001.

PART 2 INSTITUTIONAL ASPECTS

3. Existing Institutional Framework

3.1 General Background

The Union of Myanmar is composed of seven States (total population 13.0 million) in the border areas and seven divisions (total population 33.5 million) in the central area. The populations are shown in Table 10 by state and division.

Table 10 Demographic Data

Name of State	Approximate population (in millions)	Name of Division	Approximate population (in millions)
Kachin	1.20	Bago	4.85
Kayah	0.24	Sagaing	5.18
Kayin	1.40	Tanintharyi	1.27
Chin	0.46	Manadalay	6.19
Mon	2.34	Yangon	5.30
Rakhine	2.61	Ayeyarwady	6.44
Shan	4.63	Magway	4.30

Source: 1997 figures from CSO's 2000 report

There are some 324 townships in the states and divisions. The State Law and Order Restoration Council (SLORC) has held all executive powers for the Union of Myanmar since 1988. In 1997 the SLORC was renamed the State Peace and Development Council (SPDC).

The Head of State is the chairman of the SPDC. The other main members are the Vice-chairman and three Secretaries. The SPDC controls all organs of state power. Each township has its own Township Peace and Development Committee.

There are many ministers, the Prime Minister and Minister of Defence, 3 Deputy Prime Ministers, the Office of the SPDC chairman and a total of 32 Ministries in the Myanmar Government.

Myanmar (where 75% of the population live in the rural areas) has one of the lowest% of village populations with access to electricity in SE Asia as demonstrated by Table 11.

Table 11 SE Asian Countries – Rural Electrification Statistics

Country	% of total electrified villages	Country	% of total electrified villages
India	87	Sri Lanka	36
Philippines	68	Bangladesh	23
Iran	52	Laos	13
Pakistan	50	**Myanmar**	**38** (18 in rural areas)

Source: ESCAP 1995-6

There is limited Private Sector involvement in the sector, no central regulatory body and no consumer representative groups.

3.2 Stake Holders

In the context of promoting rural electrification using renewable energy sources (e.g. mini hydro, biomass, solar and wind power) the main stakeholders are perceived to be the following:

- Rural communities / Consumers
- Various ministries
- Cooperatives
- NGOs
- Private sector
- Funding agencies
- Local banks
- Contractors / fabricators
- Village electrification committees (VECs)
- Research and development organisations
- External advisors / Consultants

3.3 Relevant Organisations

From an "institutional" point of view the stakeholders include four main groups of organisations:

- Ministries and their associated enterprises
- Cooperatives
- NGOs
- VECs

These four groups are briefly discussed below:

Ministries

The main ministries / enterprises organisations currently having some involvement with rural electrification and / or the promotion of the use of renewable energy sources in Myanmar are:

- Ministry of Electric Power
  - DEP
  - MEPE
  - DHP
- Ministry of Progress of Border Areas & National Races & Development Areas
  - PBAND

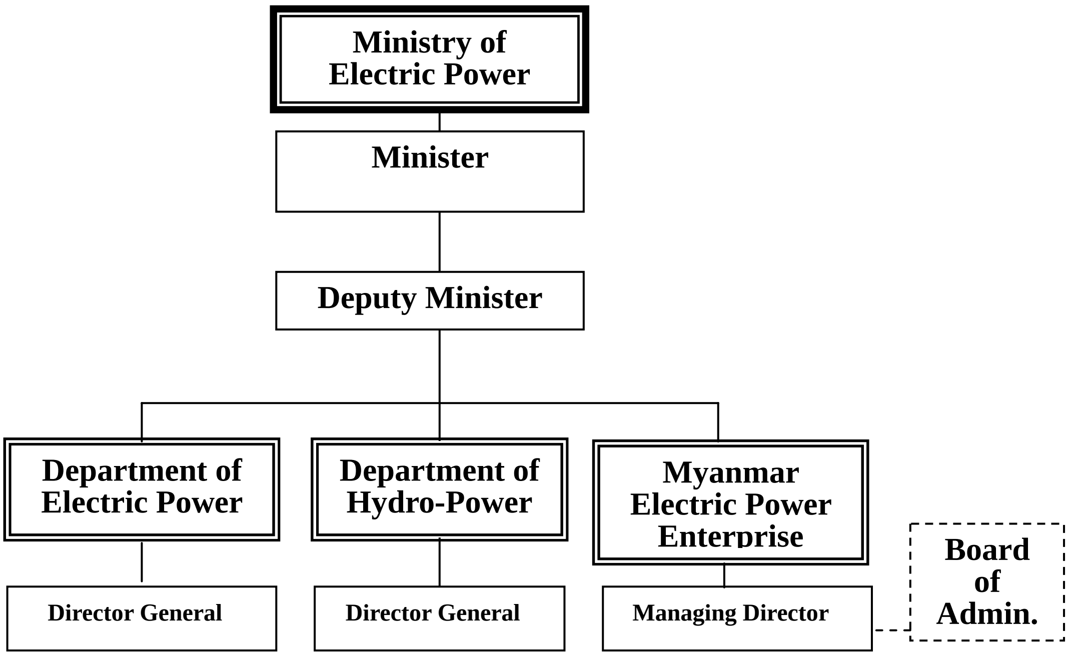
- ➢ DDA
- Ministry of Cooperatives
- Ministry of Agriculture and Irrigation
- Ministry of Energy
- Ministry of Science and Technology
- Ministry of Forestry
- Ministry of Commerce and Trade
- Ministry of Foreign Affairs / National Commission for Environmental Affairs

Of these, the main ones involved are MOEP (through MEPE) and MPBANRDA. The two ministries have already been jointly involved on several projects in the border areas. The funding for these projects has come from MPBANRDA, while MEPE has provided the engineering / O & M services.

It should be noted that MOEP and MEPE recently went through an organisational re-structuring process. MOEP established a new department (DHP) to provide planning, design and construction management services with respect to hydro power schemes (large and small). Staff were transferred from Hydel in MEPE to DHP.

DHP is planned to undergo expansion and have the capability to carry out the design and construction of complete hydro schemes i.e. without contractor involvement.

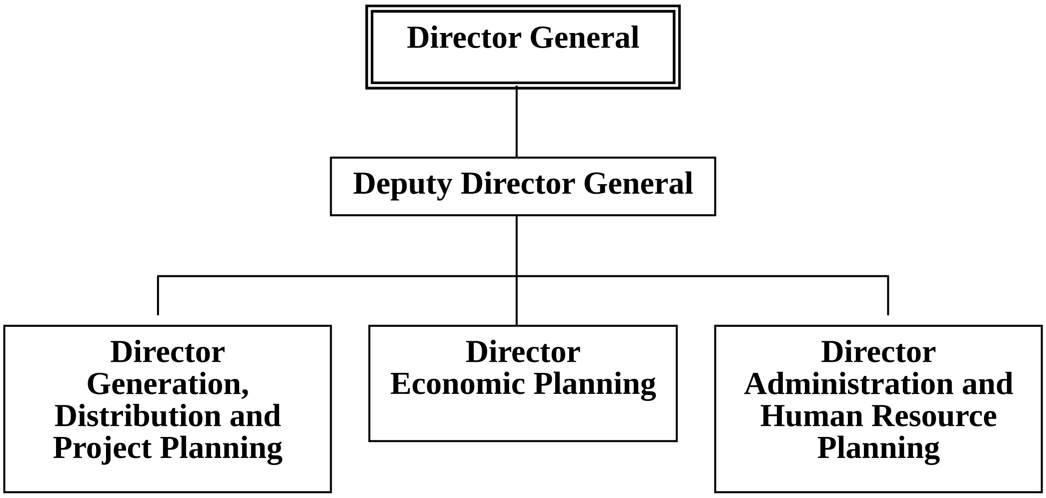
The new MOEP departmental structure is shown in Figure 6.



Source: DEP

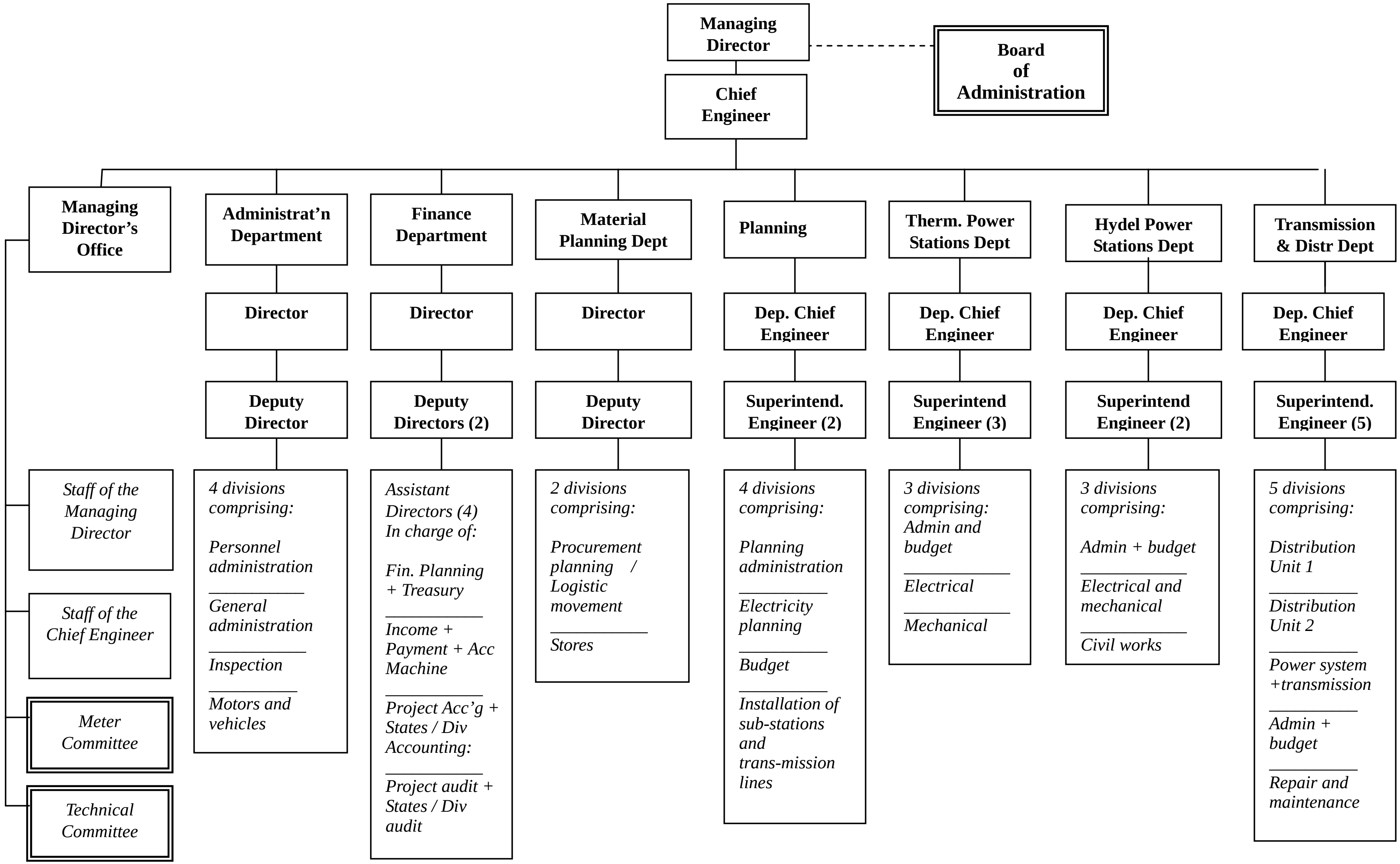
Figure 6 MOEP Departmental Structure (post 2002)

The organisational structure of MEPE following the recent restructuring and the project planning approval process of MOEP are included overleaf as Figure 8 and Figure 9. The latter diagram also illustrates the organisational structure of the new DHP. The structure of DEP showing the three directorates is in Figure 7.



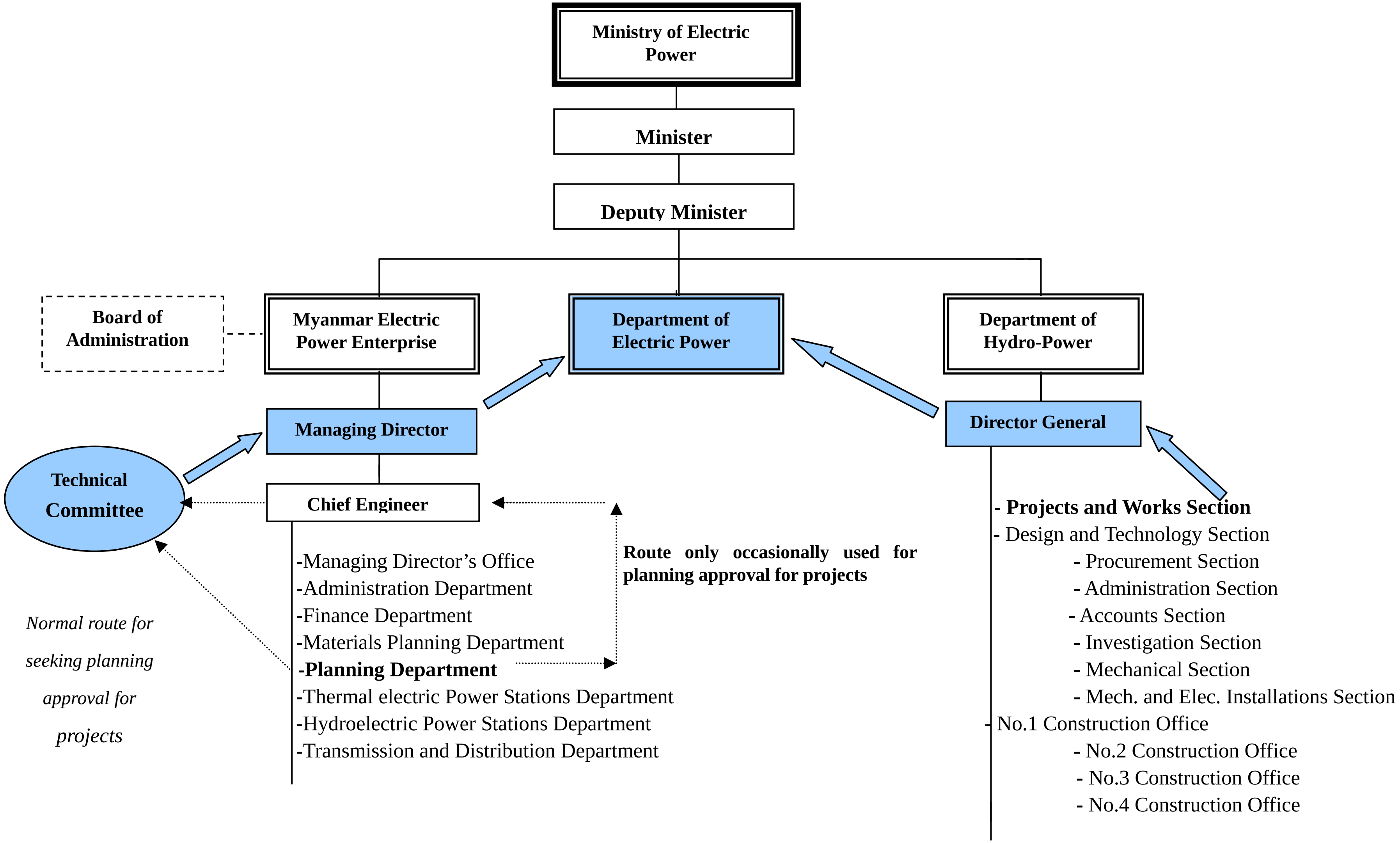
Source: DEP

Figure 7 DEP Directorates



Source: MEPE

Figure 8 Organisation Diagram (Updated Feb 03) – Myanmar Electric Power Enterprise (MEPE)



Source: DEP

Figure 9 MINISTRY OF ELECTRIC POWER Project Planning Approval Process

Cooperatives

Examples of cooperatives already active in the sector are:

- Myanmar Electric Light Co-operative Society (MELC)
- Myanmar Inventors Co-operative Ltd. (MICL)
- Sein Pann Industrial Co-operative Ltd. (SPICL)

MELC acts as a retailer of electrical goods and also carries out some small scale power supply installation services either as a sub-contractor to MEPE or independently. MICL and SPICL prefabricate components for renewable energy projects e.g. gasifier equipment (MICL), turbines & pipe work (SPICL). A few VECs are cooperatives.

NGOs

An organisation that has been active in the recent past in the sector is Renewable Energy Association Myanmar (REAM).

In 1993 the Government started a programme to encourage people to find alternative sources of energy and reduce the use of fuel-wood and it subsequently became apparent that an input from a central group would be beneficial. REAM was therefore established but does not appear to have been formally registered with the Ministry of the Home Office as an NGO.

Village Electrification Committees (VECs)

Many VECs already exist and are operating mini hydro, biomass and solar powered schemes (as well as schemes taking a bulk supply from the National Grid). Sometimes they are linked to the VPDC, some are cooperatives and others are just organised groups. Some common aspects can however be noted:

- No standard structure
- No standard rules
- Generally able to establish equitable tariffs
- Committed to serve the community
- Most are voluntary staffed

3.4 Strengths and Weaknesses

A summary of the perceived strengths and weaknesses in the existing arrangements to provide rural electrification (RE) is set out below:

Strengths

- Some work already ongoing / benefits of RE evident
- Already examples of entrepreneurship innovation and private sector involvement
- Willingness and ability to pay for the service
- Communities agreeable to participate / self fund
- Myanmar has abundant renewable energy resources
- Appropriate renewable energy technologies exist

- Skills to design and build systems exist
- Geography / topography / demography suits independent power supply systems
- Co-operative system exists and already involved in the sector

Weaknesses

- National Grid cannot meet existing demand and therefore cannot be extended to serve rural areas and this situation unlikely to change in the medium term
- No apparent ownership of the problems of meeting the RE need
- Many ministries / organisations involved but no central co-ordination
- No comprehensive RE policy / no targets
- No champion for RE using renewable energy
- Lack of funding / credit facilities and difficult for VECs or groups of villagers to get credit facilities
- Poor maintenance has affected sustainability of some existing renewable energy projects (there is also a lack of O & M manuals)
- More research and development needed (e.g. to find replacements for imported items, develop more efficient systems)
- Limited awareness from grass roots through to government level of the potential of using renewable energy for RE
- Inequitable tariffs e.g. villagers can pay many times more if on bulk meter on MEPE RE scheme
- Inadequate hand-over arrangements from contractors on some MEPE small hydro power schemes

3.5 Evidence of the Benefits of Rural Electrification (RE)

Small scale applications of renewable energy to provide RE are already apparent in some rural areas of Myanmar. The schemes include mini-hydro, biomass and solar power. They are mostly operated by VECs. RE plays a key role in reducing / counteracting the “rural – urban divide”. The benefits are shown to be:

- Increased standard of living
- Improved security and hygiene
- Higher educational achievement
- Improved economic output from cottage industries (people can work in evenings)
- Cheaper operational costs than diesel generated power
- Improved water supply through ability to pump
- Environmentally friendly concept

4. Proposed Institutional and Organisational Schemes for Rural Electrification Using Renewable Energy Sources

4.1 Roles to be Performed

From an institutional point of view, the establishment of successful and sustainable rural electrification (RE) schemes using renewable energy sources (e.g. mini hydro, biomass, solar and wind power) and replicating these within a successful long term programme, will be dependent on a number of key roles being carried out effectively. These roles, which cover both the implementation and operational aspects of the schemes, are as follows:

- "RE Champion"
- Policy making
- Planning
- Funding
- RE Scheme feasibility studies
- RE Scheme prioritisation
- RE Scheme design and construction supervision
- RE Scheme construction
- RE Scheme operation (technical) and maintenance
- RE Scheme management (administration / financial)
- Capacity building / HRD / education and training
- Management of an effective information / publicity campaign
- Monitoring and evaluation / management of feedback
- Collation of nation-wide operational data

Sustainable development is the pursuit of economic development in parallel with environmental protection. It will therefore be important to conform to national / international guidelines with respect to environmental impact assessments of proposed RE schemes. A further role has therefore to be performed in parallel with scheme implementation and operation to ensure compliance from an environmental protection viewpoint.

4.2 Organisational Options for the Various Roles

There are a number of organisational options for carrying out each of the above roles as shown in Table 12 below:

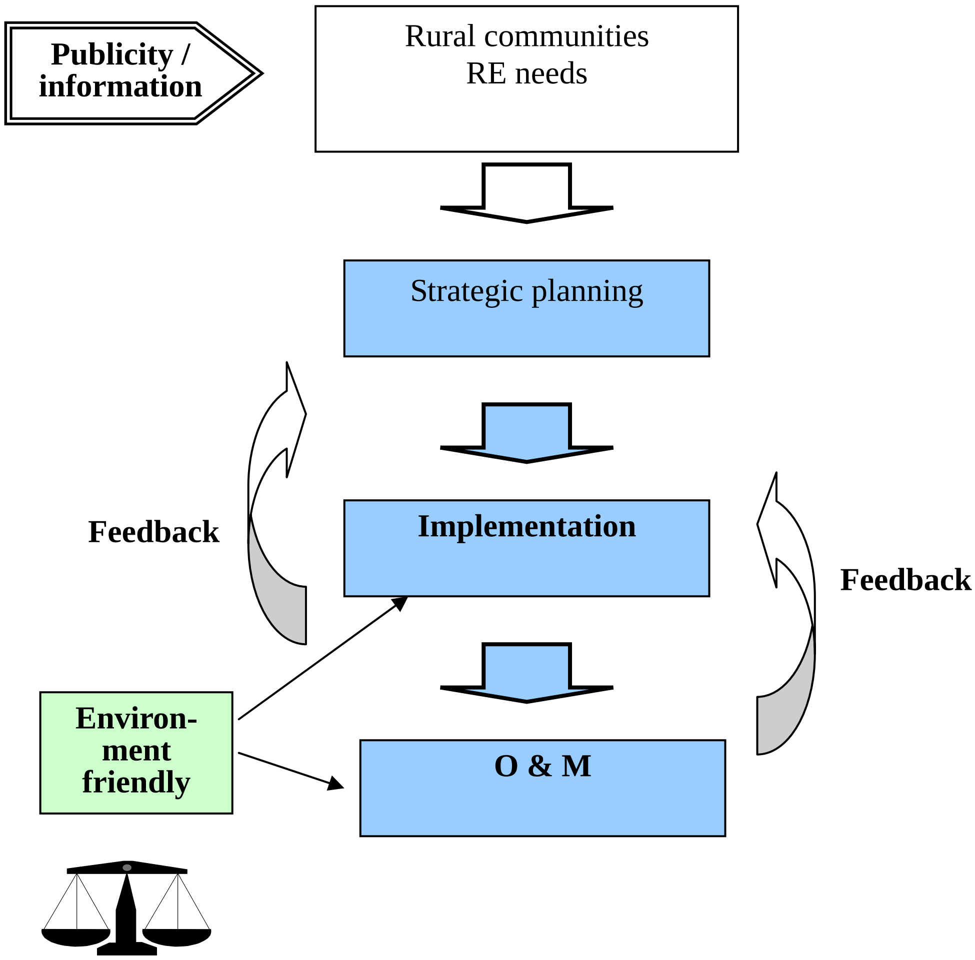
Table 12 Organisational Options for Particular Roles Related to the Promotion of Rural Electrification Using Renewable Energy Sources

Role	Organisational Options
"RE Champion"	SPDC MPBANRDA MOEP / MEPE Min. of Cooperatives
Policy making	SPDC MPBANRDA MOEP / MEPE Min. of Cooperatives
Planning	MOEP / MEPE MPBANRDA Private sector
Funding	Government MEPE MADB Aid Agencies Private sector Beneficiary community
RE Scheme feasibility studies	MEPE Private sector
RE Scheme prioritisation	MPBANRDA MEPE D / TPDC
RE Scheme design and construction supervision	MEPE Private sector
RE Scheme construction	Private sector MEPE MELC Community participation (VEC)
RE Scheme operation (technical) and maintenance	Community through VEC MEPE MELC Private sector Municipality / Township Development Committee
RE Scheme management (administration / financial)	Community through a VEC MEPE MELC Private sector Municipality / Township Development Committee
Monitoring and evaluation / management of feedback	MEPE NGO
Collation of nation-wide operational data	MOEP / MEPE MoE
Establishment of environmental protection guidelines	NCEA
Training and HRD	MEPE Local technical education institutions Local management colleges International education / training institutions

Source: JICA Study Team

Some of these options, e.g. scheme funding and scheme construction, will remain a matter of choice for the future when the most appropriate option for particular circumstances can be selected. Others, however, are more fundamental since they relate to the central process of RE scheme formulation / implementation / operation. These roles can be linked in three key functional groups as follows:

- Strategic planning = Policy making / planning / scheme prioritisation
- Implementation = Funding sourcing / Feasibility study / Design / Construction supervision
- Operations = O & M / administration / financial management
- The process for promoting and achieving sustainable RE using renewable energy sources can therefore is shown in Figure 10.

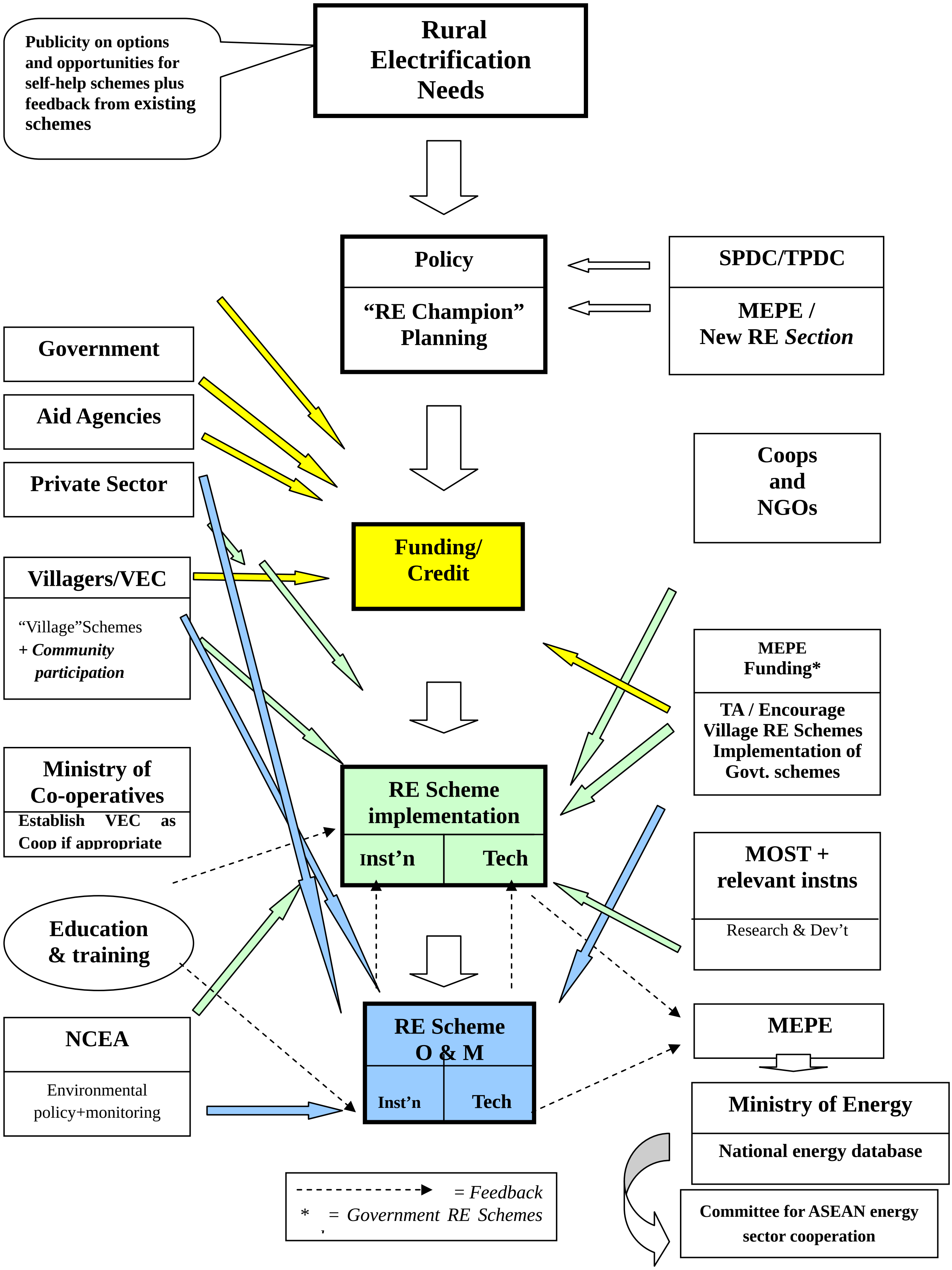


Source: JICA Study Team

Figure 10 Process for Achievement of Sustainable RE

The above 3 functional groups plus the role of "RE Champion" form the central core of the overall process of scheme implementation / operation.

The overall framework for promoting and implementing sustainable RE using renewable energy sources is shown in Figure 11



Source: JICA Study Team

Figure 11 Framework for the Implementation of Renewable Energy Projects for RE

4.3 Proposed Institutional And Organisational Arrangements

Given the options in Table 12 and the framework shown in Figure 11, the proposals for the most appropriate organisations to have responsibility for the central roles are presented in Table 13.

Table 13 Organisations Proposed for the Key Roles in RE

Role	Responsible organisation	Other organisations involved
National policy	SPDC	
Strategic planning body	MOEP / DEP	
RE Champion	MEPE	
RE scheme planning and implementation	MEPE or VECs or private sector	NGOs
RE scheme construction	Private Sector or MEPE or MELC and / or beneficiary community	Equipment fabrication cooperatives and NGOs
RE scheme operation and maintenance	MEPE or private sector or VECs	MEPE and NGOs will support VECs
Monitoring and evaluation	DEP +MEPE	NCEA

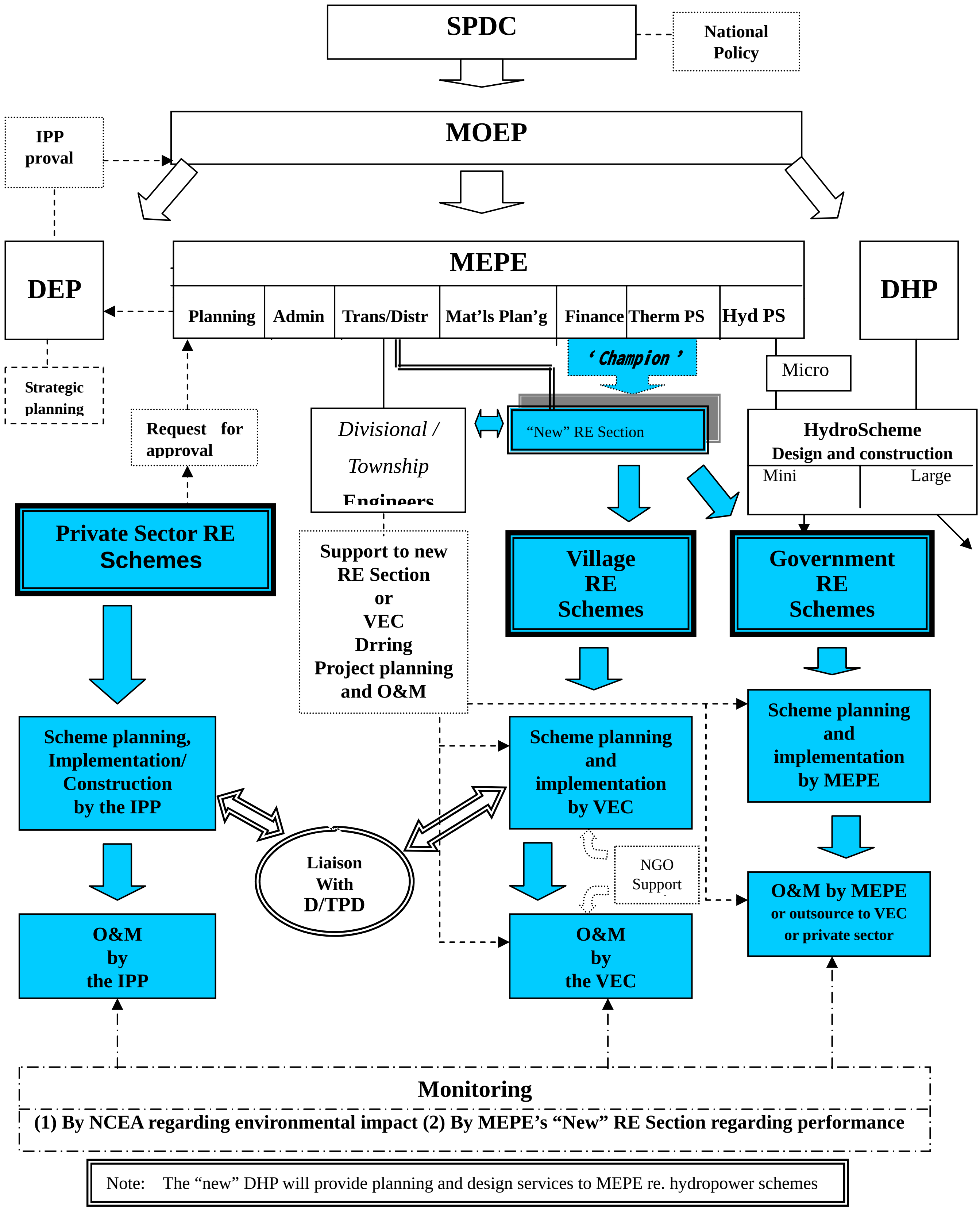
Source: JICA Study Team

Three fundamental organisational weaknesses were identified in 3.4, i.e.:

- No apparent ownership of the problems of meeting the RE need
- Many ministries / organisations involved but no central co-ordination
- No "champion" for RE using renewable energy

In order to address these issues it is proposed to establish an RE Section within MEPE. This section would come under the Transmission and Distribution Department and have responsibility for all small independent hydro power schemes undertaken by MEPE. In addition it is proposed that the section would also have a promotional and supporting role with respect to *Village RE Schemes* using renewable energy sources. The new RE Section would act as the RE "champion" and cover the full scope of services for government RE schemes, from scheme planning through implementation and O & M where appropriate. It should also manage the necessary information / publicity campaigns. If possible the existing team within MEPE forming the "Energy Sub Committee" (acting as the liaison agency for RE work in the Border Areas requested by SPDC's Works Committee) should be incorporated in the new RE Section.

The proposed organisational structure for sustainable RE is shown in Figure 12.



Source: JICA Study Team

Figure 12 Institutional and Organisational Structure for Sustainable RE

5. Policies, Laws and Regulations Necessary to Facilitate Rural Electrification Using Renewable Energy Sources

5.1 Existing Policies and Plans

The National Energy Policy is to:

- maintain the status of energy independence
- employ hydroelectric power as one vital source of energy sufficiency
- generate and distribute more electricity for economic development
- save non-renewable energy for the future energy sufficiency of our nation
- promote efficient utilization of energy and impress on energy conservation
- prevent deforestation caused by excess use of fuelwood and charcoal

MOEP's aims are to:

- employ gas turbine power generation only for short term and to rely on hydroelectric power as one vital source of energy sufficiency.
- generate and distribute more electricity for economic development.
- reduce losses and conserve electric energy for future energy sufficiency of our nation.
- promote electricity production from new and renewable sources of energy

The most relevant of MOEP's objectives in the context of renewable energy and rural electrification are to:

- identify all the hydropower sources in Myanmar and conduct feasibility studies.
- utilise internal expertise and equipment as well as imported machinery to develop mini hydropower.

The UN's ESCAP report "Commercialisation of renewable energy technologies for sustainable development" found that a cohesive national plan for research, development and implementation of renewable energy technologies did not appear to exist in Myanmar and neither did an integrated national energy planning programme.

An Energy Master Plan for Myanmar was prepared by ECFA / JGC Corporation in February 1998. The report is mainly focussed on petroleum and petroleum products but does contain some information on biomass / other forms of renewable energy and on energy policy of Myanmar. The report makes reference to an earlier ECFA report prepared in association with JDI in 1995 entitled "Comprehensive study on sustainable development for Myanmar".

MOEP formulates electric power development plans through DEP. In the last Electric Power Development Plan the capital investment priority was given to the central electric power system for city and industrial areas. MOEP prepared a 20 year plan in 1995 but this is now superseded. A 5 year plan was prepared at the same time. A new five year plan has now been prepared for the period 2001 to 2005 and the focus remains unchanged.

5.2 Existing Laws and Regulations

Laws

The only law / decree related to electric power supply is the Electricity Law 1984 which has remained unchanged since its enactment.

Other laws considered relevant to the promotion of electrification of rural areas using renewable energy are:

- The State-Owned Economic Enterprises Law 1989
- The Co-operative Society Law 1992
- Promotion of Cottage Industries Law 1991

Environmental impact assessments should be made in conjunction with all infrastructure development including renewable energy projects.

At the present time environmental law is spread across many acts but it is planned to be consolidated under a new Environmental Law (now in final draft form). The main responsibility for the environment is currently with the National Commission on Environmental Affairs which comes under the Ministry of Foreign Affairs.

There are proposals to establish a Ministry of Environmental Affairs in the near future.

A key document on environmental matters and the promotion of sustainable development is Agenda 21.

Regulations

There are 2 types of regulations covering MEPE activities:

- Ministry of Industry's regulations for Electrical Works
- MEPE's in house regulations

The Ministry of Industry's regulations, which are in Myanmar language only, do not deal with the O & M aspects of the different power generation technologies related to the various forms of renewable energy usage now under study for RE applications. The overall scope of the nine main sections of these regulations is as follows:

1. Definitions
2. 2 Permits for power generation, transmission and generation
3. Procedures for operating power generation, transmission and generation systems
4. Procedures for operating in hazardous areas
5. Procedures related to lifts, escalators and electric vehicles
6. Procedures related to the qualifying and working arrangements of skilled electricians
7. Procedures for inspecting electrical equipment
8. Procedures for inspection staff
9. Dealing with compensation

Section 2, Chapter 3, Clause 18 of the Ministry of Industry's regulations covers the procedure for issuing permits for electricity generation. This is an important aspect in the context of independent power supply systems in rural areas. Once issued these electricity production permits last for four years.

The specified limits of production are as shown in Table 14.

Table 14 Electricity Production Limits for Various Types of Permit Holders

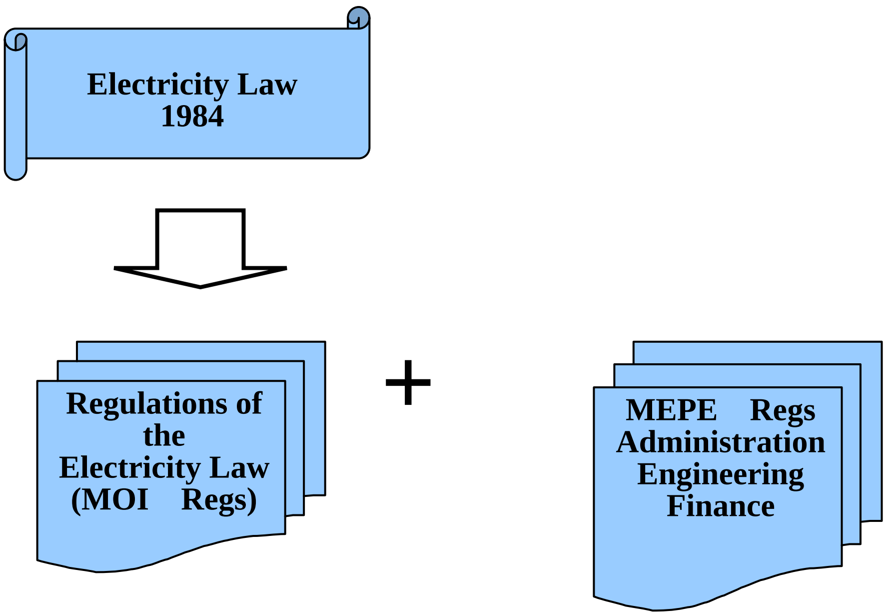
Type of permit holder	Production limit
MEPE	Unlimited kW
The Defense Units and Factories under Ministries	Unlimited kW
Cooperative Associations	750 kW
Private businesses	300 kW
Other associations	Up to 500 kW

Source: Section 2, Chapter 3, Clause 18 of the Ministry of Industry's regulations

In the past there were three books of in house regulations used by MEPE:

- Administration
- Engineering
- Finance

These regulations are also very old, sometimes not evident in regional offices, voluminous and in need of review, revision / updating and reissue. In summary, the existing legal framework is shown in Figure 13.



Source: Edited by the JICA Study Team

Figure 13 Existing Legal Framework

It should be noted that cooperatives are established in accordance with the Co-operative Society Rules 1998 and the Co-operative Society Model Bye-laws. Very few of the existing VECs in Myanmar are formally established as cooperatives. However, most have developed some form of rules and regulations.

5.3 Policies, Laws And Regulations Necessary to Facilitate Rural Electrification Using Renewable Energy Sources

In a general sense much of the necessary policy and legislation is in place. However the latter is now quite old and in need of modernisation.

Policy

In terms of policy, a major thrust to improve the level of RE would benefit from (1) a restatement by the government of its commitment to the development of the rural areas and (2) the preparation of a strategic plan (with targets and a budget) to improve the level of RE with the focus on the use of renewable energy sources / technologies.

In support of the above, effective publicity demonstrating the opportunities for self help in terms of RE (including reference to examples of what has and can be achieved) is also needed.

Laws

The Electricity Law 1984, a relatively brief document, is in need of review, expansion and modernisation.

Regulations

The MOI Regulations which support the implementation of the Electricity Law 1984 are likewise in need of review, expansion (particularly to cover the different technologies related to various forms of renewable energy) and modernisation.

There is a need for a set of model regulations to serve the VECs in their role of developing, operating, managing and maintaining small independent RE schemes. Such model regulations could form an attachment to the updated MOI Regulations. They will no doubt need tailoring in some instances to suit particular RE schemes.

6. Financial Aspects of RE Using Renewable Energy

6.1 Raising the Required Capital

Supply of electricity at initial stage of RE is typically considered to be governmental responsibility. There are two fundamental reasons of governmental involvement. One is that electricity is considered as public goods of its high social benefit. For example, the benefit of electric appliances such as light, radio, TV can be shared by family and sometimes by other community members in the public. Another reason is the economy of scale, that is, the unit cost decreases as the generating capacity becomes larger. In this regard, in principle, as far as MEPE budget can afford, the RE project had better be financed and expanded as part of the public works of MEPE, with particular emphasis on local small and mini-hydropowers (>100 kW) which would avoid long transmission lines from the Grid.

There are some exceptional cases, in which this view cannot be insisted. Such cases include 1) when the government is in short of budget and 2) when transmission and distribution lines become costly because of the long distance between the local grid and small number of consumers.

In Myanmar, there are three types of RE project that contribute to the aim of improving the current low level of RE in Myanmar:

- Government RE Schemes;
- private sector IPP schemes; and
- self-help schemes by the village communities.

Sources of funding for the first two types are self evident. As part of the driving force to promote RE, the government should inject more funds into RE sector in order to raise the rural electrification level and thereby contribute to reducing the urban / rural divide. There is also scope for the government to encourage more IPPs. IPPs should not be forced to adopt MEPE’s national tariff structure.

The third type of scheme has possibly the opportunity to make the most progress in improving the level of RE. There are already many examples of successful self-help RE schemes by rural communities in Myanmar using various forms of renewable energy.

Effective VECs have been formed for existing schemes and there is a willingness of villagers to pay for electrification despite of their low incomes.

To promote RE at least cost from the viewpoint of MEPE as well as of the whole Myanmar, the principle of self-help is important. To make the principle of self-help work, a facilitation of financial system for a small-scale loan or small-scale revolving fund should be helpful. For example, as shown in Figure 11, MEPE can help VECs to accumulate their own fund for electrification within MEPE (Section for Rural Electrification) through its local branches in the form of a revolving fund account. The accumulated fund in MEPE from many VECs can take the advantages of the scale merit. Or MEPE can manage the accumulated RE fund with the help of expertise of MADB rural branches for small scale loan.

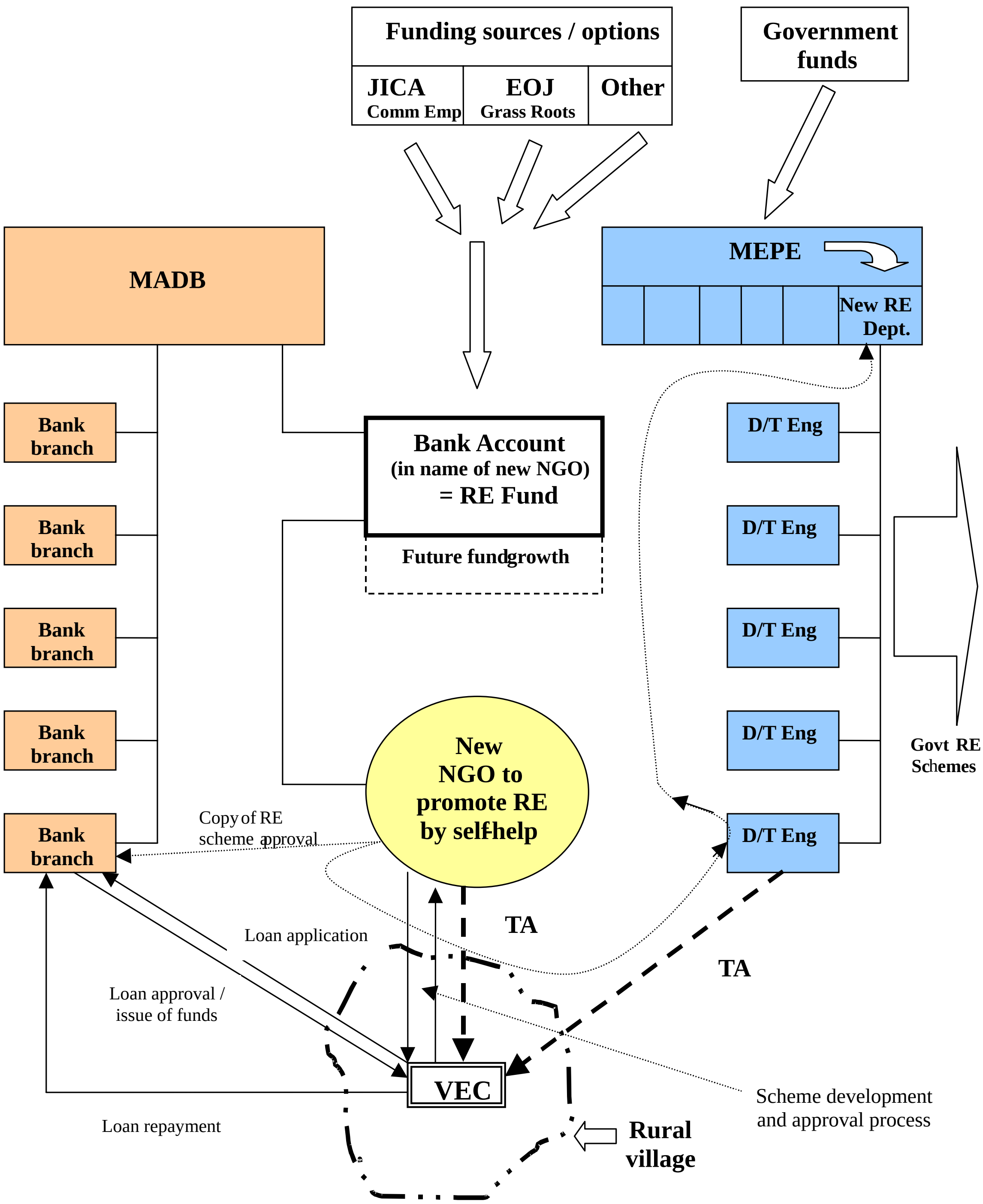
Taking account of the rural development role that MADB should offer and give through its regional network of branches, there is an opportunity to link this bank into the funding framework.

A proposed funding framework is therefore shown in Figure 14.

VECs should be allowed to establish a cost-based tariff structure. An amendment to banking rules is needed to allow loans to be made to VECs / cooperatives instead of individual villager. Requirements regarding collateral should also be reviewed.

Evidence from past projects has shown that VECs are capable of setting appropriate / acceptable tariff levels and arranging loan repayments.

From the point of RE financing, both MEPE and MADB have advantages and disadvantages as shown in Table 15. Fundamentally MEPE is strong in technical aspects and ultimately it can control the supply of electricity, while the advantage of MADB is its banking and financial expertise. For example, VEC can accumulate its own RE fund in MEPE. If MEPE alone, it would be difficult to provide extra fund beyond VEC's own fund. However, in cooperation with MADB, VEC may be provided with some extra fund beyond its savings through loan from MADB. MEPE also has such possibility as to allocate the budget for diesel engine and diesel fuel cost to introduction of renewable energy upon commissioning of the diesel substitute scheme with biomass. The last resort to prevent delinquency can be either or both MEPE's control of electricity supply and/or collateral taken by MADB.



Source: Proposal of JICA Study Team

Figure 14 Proposed Operation of RE Fund

Table 15 Advantages and Disadvantages of MEPE and MADB

	Advantages	Disadvantages
MEPE	- Technical Expertise: can control the supply—can stop the power supply in case of delinquency - Know cost and benefit - Can judge the feasibility - Have its own accountants in each township.	- Not experienced in banking service for villagers
MADB	- Banking Expertise - Existing accounts for rural residents - Funding source is government - Authorized to make loan and to take collateral	- Not familiar with technical aspects - Cannot judge the feasibility of RE

Source: JICA Study Team

6.2 Tariff Structures and Level

Those utilities (IPP) who plan to sell electricity must submit an application to MOEP, and shall get approval of relevant agencies (MOEP, Myanma Investment Committee (MIC), Trade Council, and Cabinet depending on the nature and scale of the scheme). However, those schemes for self-consumption do not need such approval.

In the case of rural electrification as a small scale IPP scheme by the private sector, it will be required to apply to MOEP and get its approval.

In the case of rural electrification by VEC, it is a kind of self-consumption and is different from commercial electricity business. VEC may be established as a non-profit organization under VPDC. Although there is no written rule, VEC should report to MOEP through MEPE Township Office on the RE scheme for the purpose of nationwide statistics and future planning of power supply by the grid extension.

It is the principle of DEP that MEPE's tariff system and level be uniformly applied nationwide.

However, in the case of rural electrification by VEC on a self-help basis, raising of the initial fund and operating expenses from among the villagers is different from tariff collection of electricity business and would not conflict with the principle above for the uniform tariff nationwide.

6.3 Control of Non-technical Losses

Non-technical losses can be attributed to the way of use of electricity by customers or non-customers by various means, which include illegal connection and use of electricity. Although there are no comparable statistics, non-technical losses are conceivable from the Grid compared to the community-based self-supply RE. For the case of an illegal connection to the Grid, there is no direct damage to neighbourers from his connection and, therefore, the neighbourers have little concern. Only MEPE or general public receive the losses.

In this regard, the non-technical loss would be small for self-help RE scheme.

In the case of the illegal connection to or use of the Grid, there may be two countermeasures for the reduction in the losses; 1) to prevent illegal connection/use and 2) to penalize it.

To prevent illegal connections, MEPE recently reinforced the monitoring practices including random inspection of customers and clarification of the accountability of linesmen of MEPE.

Penalty to illegal connection has to be reinforced. The penalties are 1) stop supplying power to those households that do not pay tariff or delayed payment for more than a certain period, 2) fine to illegal wiring to the Grid in particular, 3) fine to those uses other than contracted purpose in the Grid, such as opening BCS under general category contract with MEPE.

The best countermeasure should be to place the meter box on the outside wall of each customer and to use insulated conductors for low tension and 11 kV distribution lines.

7. Use of the Electricity Generated for Economic Production

As typical economic power demand in the rural area of Myanmar, the following are conceivable:

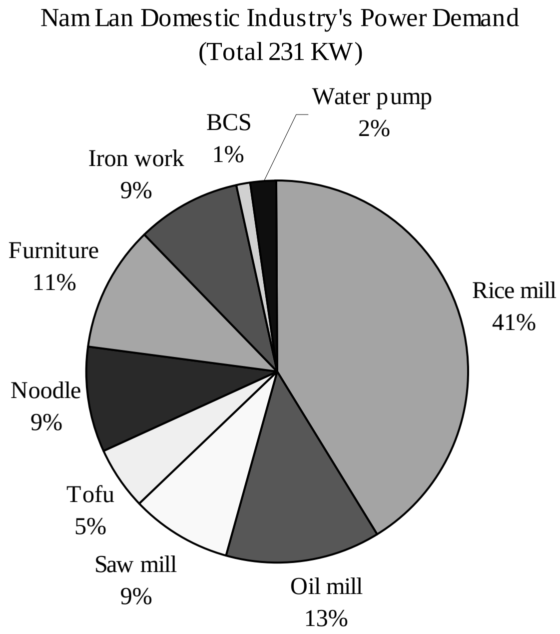
- textile, tailor, sewing;
- sawmills, furniture, wood weaving;
- oil-mill, rice-mill, farm-gate pre-processing of sugarcane;
- drying vermicelli, beans;
- ice producer;
- water supply pump, irrigation pump;
- BCS for battery charging;
- restaurants (lighting, refrigerators, heating);
- video theaters, Karaoke shop, film theater; and
- retail shops.

Figure 15 presents assumed shares of these economic demand when all the diesel engines for these industries in Nam Lan townships (one of the three priority projects proposed and elaborated under the Study, and quoted here as an example) are replaced by electric motors. The total electric power consumption is estimated to be about 310 kW (see demand forecast of Nam Lan RE Scheme in Vol. 5). The total consumption from 8 a.m. to 4 p.m. would be in an order of 310 x 8 = 2,480 kWh/day. Because the industries are using the mechanical power directly from diesel engine, the actual power substituted by electricity will be slightly smaller. Assuming motor efficiency of about 86% (average standard motors of 15 HP), the required energy input to the industries would be 2,480 x 0.86 = 2,130 kWh/day. To provide this amount of electricity by diesel engine, the required diesel oil is about 213 gallon = 2,130 kWh / 10 (kWh/gallon of diesel in Myanmar) with efficiency of about 19%. The monthly cost is about 213 gallon x 30 days x $1.00/gallon = $6,390/month. Because there are about 50 such domestic industries, the monthly cost is estimated to be about $127 per industry.

One of the domestic industries will consume nearly 2,130 kWh/day x 30 days / 50 industries = 1,280 kWh/month/industry on an average. Under MEPE tariff schedule, the electricity bill will be more than K28,000 ($57, energy charge K25/kWh above 200 kWh) for each domestic industry. This is only 45% of the economic cost of diesel oil. In comparison with economic benefit, both the nighttime users and daytime users pay far less than the economic value of the electricity.

There is clear distinction that the nighttime users consume less power but are large in the number while the industrial users consume large power but are small in the number.

Introduction of annual fee in the name of contract renewal or membership fee of VEC, which is different between non-daytime users and daytime users, may be worth considering. For example, annual membership fee may be set at $10 for nighttime lighting users (or users of 50 kWh/month or less) in addition to MEPE tariff and $50 for daytime users (or users of 50 kWh/month or more).



Source: JICA Study Team

Figure 15 Forecast Daytime Demand of Nam Lan RE Scheme

In the Central Dry Zone (CDZ) in particular, the power for pumping up groundwater through deep wells (300 m) and the power for pump irrigation are the indispensable resources.

On the Shan Plateau and in Kachin State, there are certain demands for heating in the winter season and demand for hot water for shower in the tourist hotels.

There is power demand for drying agriculture and agro-industry products like garlic in Shan. At present, garlic is transported from Shan to CDZ for natural drying under sunshine.

As the demand of public facilities in the villages, the following are conceivable:

- primary schools (up to 4th grade) and middle school;
- community center often in the monastery;
- monastery;
- library attached with IT education facility;
- Rural health center (RHC), clinic;
- Village office.

8. Operation and Maintenance Schemes for Power Supply Systems Using Renewable Energy Sources

8.1 Status of Existing O & M of Isolated RE Schemes

Operation and maintenance of existing independent electrification systems in the rural areas of Myanmar (i.e. all systems outside the Grid) is generally carried out by one of the following two organisations:

- MEPE
- VECs

The independent systems operated and maintained by MEPE are either small hydropower schemes or diesel generator plants and include those in the border areas promoted / owned by MPBANRDA.

The systems operated and maintained by VECs cover a wider range and comprise the following:

- small hydropower schemes
- diesel powered generation schemes
- solar powered battery charging schemes
- solar powered village domestic water supply systems
- biomass (rice husk) schemes

There are also cases where VECs operate and maintain rural electrification systems which take a bulk supply from the Grid e.g. Heya Ywama village near Inle Lake and Bambawe village.

VECs have usually been set up on an ad hoc basis with some external assistance e.g. from MEPE or NGOs such as REAM or the Ministry of Cooperatives or the equipment / technology supplier.

Given the low level of rural electrification in Myanmar the number of independent power supply systems is rather limited. However, some common problems currently affecting operation and maintenance can be identified and include:

- remoteness of some schemes makes getting parts / materials difficult
- shortage of some spare parts and materials due to non-availability in the local market
- shortage of proper tools
- high cost of some spare parts, materials and fuel (e.g. diesel)
- no O & M manuals
- no preventive maintenance ("fix it when it breaks" approach adopted)
- inability to buy appropriate materials (e.g. distilled water for batteries)
- relatively short life of some components e.g. the softwood poles normally used for power distribution
- no standard regulations / guidelines for operating organisations (VECs)

- inappropriate O & M organisational structure
- no national structure to support small independent power producers

These issues need to be addressed in developing a framework for the sustainable operation and maintenance of independent power production / supply systems in the future.

8.2 Scope of Future Renewable Energy / RE Schemes

The most potential for making a positive impact on the level of rural electrification using renewable energy applications would seem to be by developing small hydropower schemes and by producing power from biomass gasification. The technology for both these systems is relatively straightforward and already in use in Myanmar and therefore neither application will create extra ordinary demands in relation to operation and maintenance needs.

8.3 Requirements for Effective O &M

In order to achieve sustainability, a number of key factors need to be in place in order to ensure that an independent power supply system is operated and maintained effectively. These are:

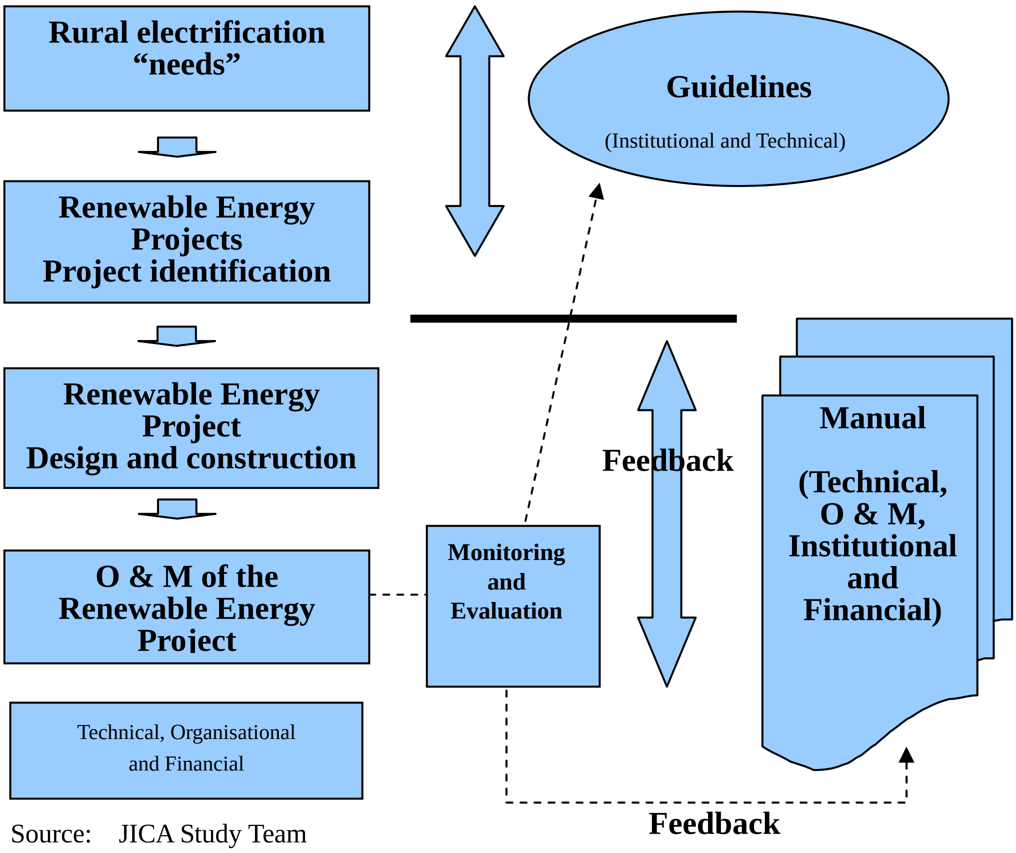
- a properly set up operational management organisation
- O & M manuals and guidelines
- trained O & M staff
- availability of spare parts and maintenance materials
- adequate funding
- appropriate and equitable tariff structure
- efficient billing and collection procedures
- transparency in financial matters
- good communications with consumers
- monitoring and evaluation of the process
- technical support from MEPE and / or NGOs

It is also important that there is feedback from the operation and maintenance process to the design and construction processes. By this means the lessons learned during the working life of a renewable energy RE scheme can lead to future improvements in these areas and produce more efficiency and improve sustainability.

8.4 Proposed O & M Framework for Future Renewable Energy / RE Schemes

The Guidelines are essentially intended to cover the management processes through to project selection. The details of O & M are covered in the Manuals both from a technical point of view and regarding the institutional aspects.

The linkage between the Guidelines and the Manual is shown in Figure 16.



Source: JICA Study Team

Figure 16 Linkage Between Roles of the Guidelines and the Manuals

9. Framework for the Development of Human Resources

9.1 Existing Training Organisations and Arrangements in the Sector

MEPE

Training within the MOEP is one of the responsibilities of the Planning Directorate in DEP. There is no training college or a department to serve MEPE. The training is carried out by DEP and MEPE staff in a large room at the rear of the compound dedicated to training.

There are two "general orientation" training courses each year and it is for junior engineers and covers engineering, finance and management. Each course lasts for three months and is full time. Normally there are between 50-60 participants selected by the Divisional Engineers.

No training is given to finance staff (apart from induction training at the Government Staff College– see below).

Renewable Energy Association Myanmar (REAM)

REAM produced several training packages in the past for training to be carried out by associates. Areas covered by their training packages have included:

- Community education
- Solar panel systems
- Technician training
- Fire-wood substitute / fuel efficient stoves

MOST / MSTRD

This Ministry through one of their key R & D departments is able to offer "technology related" training.

Ministry of Cooperatives

Training is available from the Cottage Industries Department.

Universities

Most have HRD departments and provide courses for internal and external students.

Government Staff College / Phaung Gyi

Provides a form of induction training for government staff of different levels following their entry into government service. (One college is in Yangon and another in Mandalay). Courses are full-time and of three to four months duration.

All staff have to have attended this course which covers administration, finance, engineering, politics and government rules and regulations.

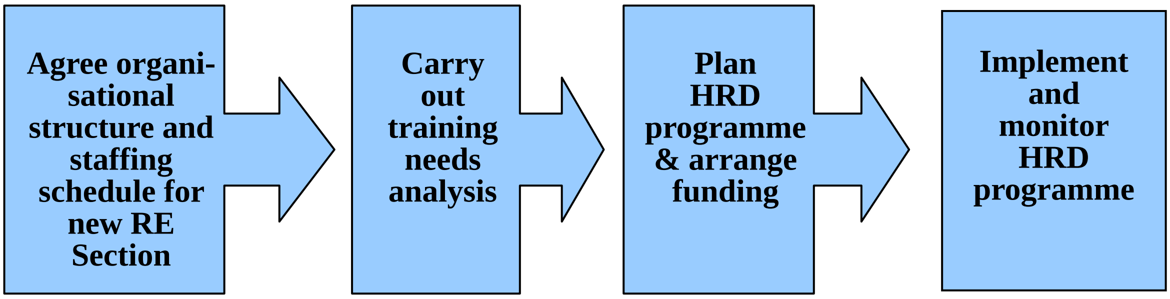
External (0ffshore) training arrangements / organisations

In addition to "in-house" training, many MEPE staff at different levels have gone abroad for training under sponsorship schemes (e.g. JICA).

Relevant courses for key managers are available regionally. An example of an institution offering these is The Asian Institute of Management (AIM) – Manila, Philippines. The AIM offers degree and non-degree-training programs in development management which include subjects areas of special interest, such as strategic planning and development master planning. One relevant module is the Program and Project Development and Management (PPDM), an intensive four-week course designed to develop the operational skills needed in each phase of the project cycle, as well at the strategic skills required to integrate and package projects into effective and sustainable programs. The PPDM course sets out to develop effective managers by equipping them with skills, tools, and techniques needed to manage the cycle from conceptualisation and design, to implementation and evaluation.

9.2 Training Needs

A training needs analysis will need to be carried as a subsequent step in the capacity building process. The components in the process are shown in Figure 17.



Source: Proposal of JICA Study Team

Figure 17 Capacity Building Process

Prior to doing the training needs analysis, a preliminary assessment indicates that there is a need for:

- Engineers who can plan, build, operate and maintain *Village Hydros* less than 50 kW
- The development of strategic planning and policy analysis skills for management
- An awareness by management and engineers of the importance of social dimensions in RE scheme development e.g. social factors that contribute to sustainability,
- Training in all aspects of running VECs / operating small independent RE schemes (implementation, community participation, operational management, administration and financial management)
- Specific technical training e.g. on O & M of gas engines

9.3 Framework for the Development of Human Resources

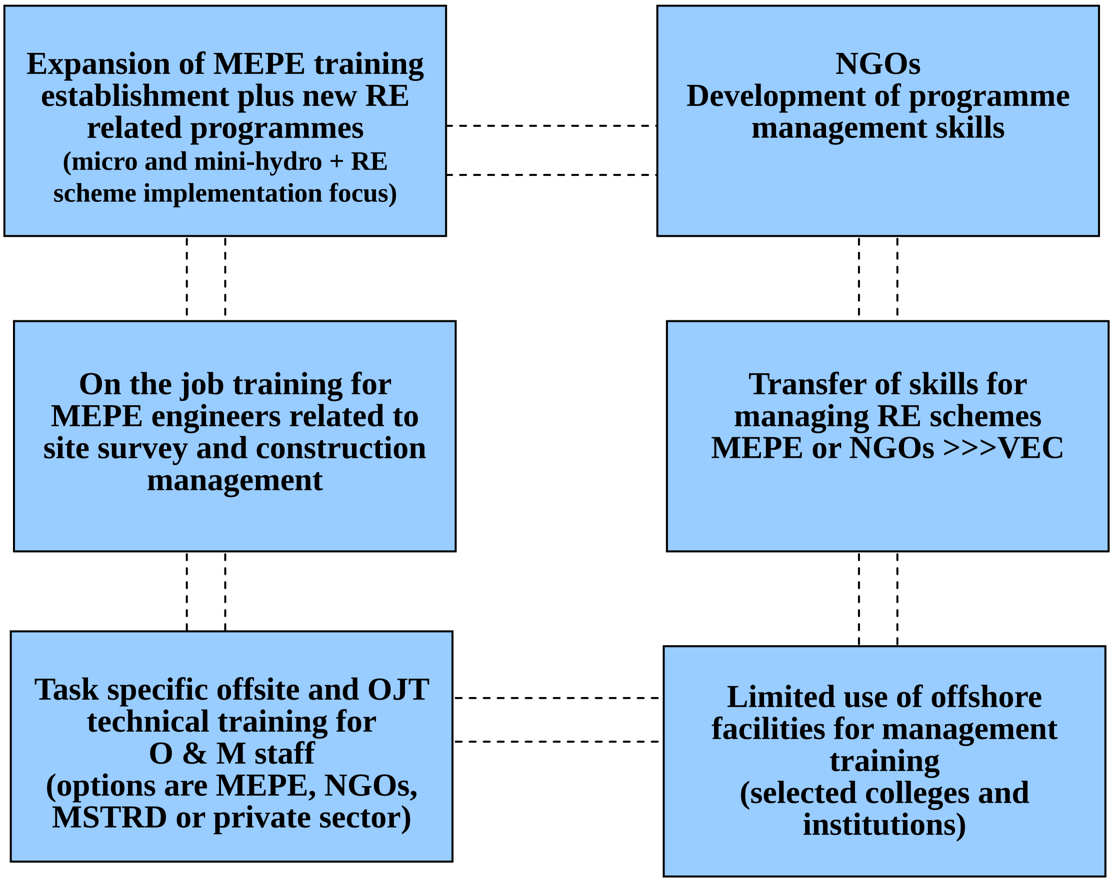
In order to address the skills shortage of engineers for RE schemes using renewable energy it is proposed to develop the MEPE training centre in Yangon as the focus for capacity building of staff from the divisional offices. The trained staff will, in turn, guide and support the VECs on the small schemes.

A summary of the main areas where capacity building is needed is given in Table 16 together with the related training options. The overall framework for the development of HRD is shown in Figure 18.

Table 16 Summary of Areas Needing HRD and the Options for Training

Areas needing capacity building / HRD	Options of potential sources of training or skills transfer
Engineers – mini-hydro design and project management skills	MEPE
Engineers – site survey / investigation and construction management	On the job training arranged by MEPE
Management – strategic planning, social components in development of RE projects.	External sources
NGOs – programme management	Consultant
VECs – implementation, community participation, operational management, administration and financial management	MEPE + NGOs
Operation and maintenance staff – technical and operational safety aspects of particular technologies	MEPE + NGOs + MICL + MSTRD

Source: JICA Study Team



Source: JICA Study Team

Figure 18 HRD Framework

PART 3 TECHNICAL ASPECTS

10. Development Potentials of Renewable Energy for RE

10.1 Small Hydropower

Table 17 lists up those small hydropower projects that DHP identified and made reconnaissance and preliminary study.

Table 17 Numbers of Sites and Capacities of Small Hydros Greater than 100 kW

No.	State & Division	Under 1.0 MW								1.0 MW to 10.0 MW								Under 1.0 M W to 10MW Total	
		Installed		Under Construction		Under Study		Total		Installed		Under Construction		Under Study		Total			
		No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)	No: of Prj	Capacity (MW)
1	Kachin State	3	0.470	-	-	16	4.708	19	5.178	3	8.780	1	6.000	9	35.220	13	50.000	32	55.178
2	Kayah State	1	0.108	-	-	1	0.050	2	0.158	-	-	-	-	-	-	-	-	2	0.158
3	Kayin State	1	0.037	-	-	7	1.372	8	1.409	-	-	-	-	4	10.000	4	10.000	12	11.409
4	Chin State	8	2.310	-	-	8	1.820	16	4.130	1	1.000	-	-	2	3.000	3	4.000	19	8.130
5	Sagaing Division	1	0.050	-	-	11	2.565	12	2.615	1	1.260	-	-	2	3.300	3	4.560	15	7.175
6	Tanintharyi Division	2	0.342	-	-	6	1.210	8	1.552	-	-	-	-	1	9.000	1	9.000	9	10.552
7	Bago Division	-	-	-	-	4	1.890	4	1.890	-	-	-	-	1	2.000	1	2.000	5	3.890
8	Magway Division	-	-	-	-	2	0.400	2	0.400	-	-	-	-	3	19.200	3	19.200	5	19.600
9	Mandalay Division	1	0.450	-	-	5	0.264	6	0.714	1	4.000	-	-	1	2.250	2	6.250	8	6.964
10	Mon State	1	0.198	-	-	6	0.725	7	0.923	-	-	-	-	2	11.500	2	11.500	9	12.423
11	Rakhine State	-	-	-	-	9	1.673	9	1.673	-	-	-	-	1	1.500	1	1.500	10	3.173
12	Shan State	10	2.116	1	0.320	37	12.550	48	14.986	6	24.000	1	2.000	16	44.160	23	70.160	71	85.146
	Total	28	6.081	1	0.320	112	29.227	141	35.628	12	39.040	2	8.000	42	141.130	56	188.170	197	223.798

Source: DHP

There are 197 small hydropower schemes identified (<10 MW). Of these, 40 numbers are installed, three are under construction, and 154 are under study. The potential schemes have a total installed capacity of 170 MW.

The existing small hydropower stations of MEPE (<10 MW) amount to 30 plants and 40 MW in total installed capacity.

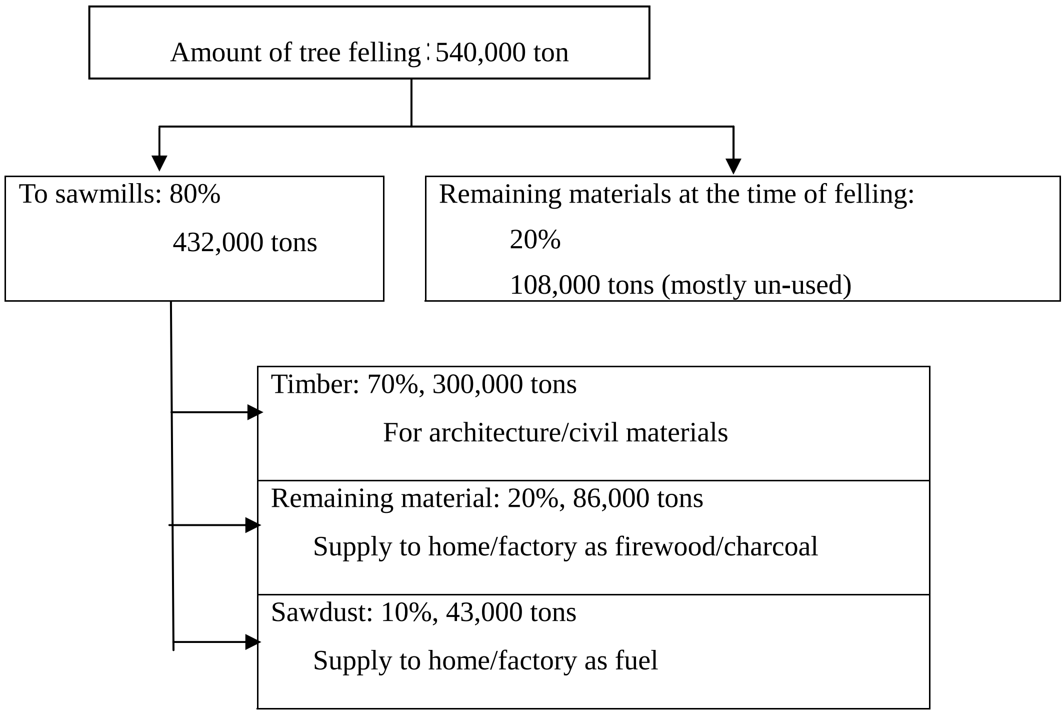
In addition to these, there are many *Village Hydro* and Pico hydro potentials. However, a database of these small schemes have not been established except for those presented in Appendix-1.

Shan State has the largest number of hydro-sites being 71, followed by Kachin 32, Chin 19, and Sagaing 15.

10.2 Biomass Potential

Wood Biomass

As for the sawmills under the management of the Ministry of Forestry, there are 85 plants in the whole country. The production quantity is about 430,000 wood-ton per year (1 wood-ton equivalent to 50 ft^3). The production and flow of timbers are as shown in Figure 19.



Source: Myanmar Timber Enterprise, Ministry of Forestry, 1999

Figure 19 Timber Production and Wood Chips

Assuming the tree-felling amount of private sawmills is same as that of public sawmills above, the gross weight of wood chips and sawdust would be:

(86,000 + 43,000) x 2 = 258,000 tons

The 258,000 tons of wood has calorie of 1.29×10^{12} kcal at an assumed unit calorie of 5,000 kcal/kg. This corresponds to 129,000 toe (1.0 toe = 10^7 kcal). Timber and charcoal will be used as the main fuel for cooking in rural areas in Myanmar in the short to medium-term. If wood fuel is not used for cooking in the future, it will be possible to introduce wood combustion steam turbine or wood gasification system for power generation.

If the remaining materials (wood chip) 86,000 tons at sawmills can be used for power generation with gas engine in the future when there is no other demand for wood chip, it would have potential of some 25,000 kW:

- wood chip to be collected: 86,000 tons
- calorific value of wood: 5,000 kcal/kg

- efficiency of engine-generator: assumed at 11%
- energy output of generator: 5,000 kcal/kg x 86,000 tonnes x 1,000 kg x 0.11

  = 47×10^9 kcal / 860 kcal/kWh

  = 55 GWh
- plant factor: assumed at 0.25 (6 hour operation a day)
- power output: 55×10^6 kWh / (24 x 365 x 0.25)

  = 25 MW

In addition to the wood chip from sawmills, there are the other types of biomass such as aged rubber trees, cob and stalks of maize, reed, etc. These could be potential fuel for gasifier by pylorysis and could replace some diesel generators of MEPE.

However, the following study and prototype experiment will be required before materializing commercial use of these biomass resources:

- study on the distribution and economic method for collection of these biomass;
- study on the need of producing wood chips or pellets before feeding waste wood to the gasifier;
- prototype experiment of gasifier and engine generator;
- synchronized operation of multiple engine generators and distribution through 11 kV lines.

Rice Husks

Paddy production in Myanmar was 17.4 million tonnes in 1997/98. As husk portion occupies 20% of the paddy weight, the yield of husk was 3,480,000 tons. With a unit calorie at about 3,000 kcal/kg, the rice husks in gross correspond to 1,040,000 toe.

There are two types of rice-mills existing in Myanmar. One is full-scale rice-mill having special machines that remove rice husk from paddy prior to rice whitening process. Normally this type is of medium and large-scale rice-mills having processing capacity of more than 1 tonne of paddy per hour. The other type is a small-scale rice-mill (capacity is around 500 kg/hour) where paddy is fed into friction type rice whitening chamber without particular husk removing process. This type produces milled rice and mixture of broken husks and rice bran. The rice husks from the former large mills can be used as fuel for combustion but the mixture from the latter small mills is normally consumed as feed for the poultry. The small scale rice-mills are existing at each village for processing of paddy for self-consumption. (However, the information needs checking and confirmation since small rice-mills of 2.5 tonne/day inspected in the villages around Yangon separated husks from rice bran and husk is available as fuel.)

Table 18 presents population, paddy production, rice husk production, and rice husk power potential by division/state. Ayeyarwady division and Bago division are two major paddy production regions, followed by Yangon division and Sagaing division.

If 20% of all the rice husks are used for power generation with husk gas engines for 6 hours a day (to meet lighting demand in the evening), it has a potential power of 127 MW (Table 18). With unit consumption of 80 W per household and family size of 6, this power can electrify about 1.6 million households or 10 million people. This is a significant potential in comparison with the number of MEPE consumers at 1.025 million in 2000/01, or with the national population of 47 million in 1998.

Table 19 presents number of large scale commercial rice-mills by capacity and division/state, and Table 20 rice husk power potential. A total of 1,579 commercial rice-mills produce about two thirds of the rice husk in Myanmar (2.3 / 3.5 million tonne).

The rice husk discharged from commercial rice-mills is estimated at 2,340,000 tonnes a year, which have a potential to generate electricity of 936 GWh by husk gas engine generator at an assumed unit husk consumption rate of 2.5 kg/kWh. This corresponds to 19% of MEPE's total power generation of 5,020 GWh in whole Myanmar in 2000/01.

The rice husk is widely in use as the power sources of rice-mills, the heat source for alcohol brewery, brick factory and for the cooking fuel of homes in the vicinity of rice-mills. Accordingly, it is important for basic planning of rural electrification with the husk gas engine to check the existing husk demand to the rice-mills nearby the village of interest.

If the rice-mill uses an outdated smoke-cube boiler with rice husk and steam engine system, there is a possibility to improve the power generation system and to save husk consumption. Such system has a very low heat efficiency and consumes a large quantity of husk. It is possible to replace the smoke-cube boiler with the gasification engine to have extra husks for rural electrification.

Table 18 Population, Production of Paddy and Rice Husk, and Power Potential

No.	State/Division	Population in 1997	Paddy Production in 1996-1997	Paddy Production per capita	Rice Husk Production	Potential Energy	Potential Power
		1,000	1,000 ton	kg	1,000 ton	GWh	kW
		1	2	3	4	5	6
1	Kachin State	1,202	315	262	63	5	2,280
2	Kayah State	246	76	310	15	1	550
3	Kayin State	1,403	454	324	91	7	3,330
4	Chin State	458	66	144	13	1	500
5	Sagaing Division	5,180	1,564	302	313	25	11,420
6	Tanintharyi Division	1,269	231	182	46	4	1,690
7	Bago Division	4,848	2,930	604	586	47	21,420
8	Magway Division	4,301	576	134	115	9	4,200
9	Mandalay Division	6,188	913	148	183	15	6,670
10	Mon State	2,337	889	380	178	14	6,480
11	Rakhine State	2,610	925	354	185	15	6,760
12	Yangon Division	5,295	1,623	306	325	26	11,870
13	Shan State	4,629	942	203	188	15	6,890
14	Ayeyarwady Divisior	6,436	5,894	916	1,179	94	43,060
	Union Total	46,402	17,397	375	3,480	278	127,120

Source: Power potential by JICA Study Team
Population by Statistical Yearbook 2000, Central Statistical Organization, Yangon, Myanmar, 2000, Ministry of National Planning and Economic Development

Paddy by Agricultural Statistics (1987-88 to 1997-98), Yangon, Myanmar, 1999, Central Statistical Organization, Ministry of National Planning and Economic Development in Collaboration with Department of Agricultural Planning, Ministry of Agriculture and Irrigation

Note: Potentail energy and potential power are estimated assuming 20% of the rice husk produced in the State/Division can be used for power generation.
Potential energy is calculated on the assumption that 2.5 kg of rice husk can generate 1 kWh of electricity by the gas engine generator.
Potential peak power for evening lighting is estimated on the basis of assumed plant factor of 0.25, that is, 6 hour operation a day.

Table 19 Number of Rice-mills and Rice Husk Power Potential by Capacity and State

No.	Rice Mill Capacity (t/d)	10<	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-70	71-75	76-100	100<	Total nos.
	Av. Capacity (t/d)	5	13	18	23	28	33	38	43	48	53	58	65	73	88	150	
	Potential Power (kW)	12	31	43	55	67	79	91	103	115	127	139	156	175	211	359	
1	Ayeyarwaddy	0	228	175	87	53	12	15	22	18	5	8	0	4	1	14	642
2	Bago	0	123	34	80	15	1	19	3	12	2	3	2	4	0	5	303
3	Yangon	0	127	22	21	6	1	17	2	5	0	1	0	2	0	8	212
4	Sagaing	2	20	43	49	6	0	0	0	1	0	0	0	0	0	0	121
5	Mon	2	65	7	7	9	0	8	3	0	1	1	0	1	0	0	104
6	Mandalay	4	58	5	8	4	0	3	0	0	0	0	0	0	0	0	82
7	Kachin	14	12	1	1	3	0	0	0	0	0	0	0	0	0	0	31
8	Magway	0	9	4	14	2	0	0	0	0	0	0	0	0	0	0	29
9	Tanintharyi	0	15	1	1	0	0	0	0	0	0	0	0	0	0	0	17
10	Rakhine	1	15	0	5	0	0	1	0	0	0	0	0	3	0	0	25
11	Kayah	0	2	4	2	0	0	0	0	0	0	0	0	0	0	0	8
12	Shan	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
	Total (nos. of PGU)	28	674	296	275	98	14	63	30	36	8	13	2	14	1	27	1,579
	Power output (MW)	0.3	20.9	12.7	15.1	6.6	1.1	5.7	3.1	4.1	1.0	1.8	0.3	2.5	0.2	9.7	85.1

Av. Capacity:	Average capacity of the rice mill in white rice output per 24 hour operation per day.
	Milling recovery (white rice amount from paddy) is 0.61 as per MAPT's standards.
Husk disposal per Hour:	(Av. capa ÷ 0.61) ÷ 24 hours x 0.2 Husk amount is approx. 20% of paddy weight.
PGU capacity:	1 kWh requires 2.5 kg of husk by gas-engine, thus husk amount ÷ 2.5 kg/kWh = Electric power output
Plant Factor:	0.25 (6 hour operation a day). Therefor (PGU average ouput) ÷ 0.25 = Installed capacity of power plant
Example for 23 ton rice mill:	Paddy amount can be milled per day: 23 ÷ 0.61 = 38 ton/24hr (1.58 ton/hour)
	Husk amount can be available per hour: 20% of paddy (1.58 x 0.2 = 0.316 ton = 316 kg)
	Electric power generation capacity: 2.5 kg of husk can generate 1 kWh ; 316 ÷ 2.5 = 126 kW
	Rice mill operation rate: 8hours/24hrs and 120days/365days ; 126 kW x (8/24) x (120/365) = 13.8 kWh/day --> ÷ 0.25 = 55 kW x 6 hours/da

Source: JICA Study Team with rice-mill data from MAPT.

Table 20 Potential Power of Rice Husk by Size of Rice-mill and State/Division

No.	Rice Mill Capacity (t/d)	10<	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-70	71-75	76-100	100<	Total Power Potential
	Av. Capacity (t/d)	5	13	18	23	28	33	38	43	48	53	58	65	73	88	150	
	Potential Power (kW)	12	31	43	55	67	79	91	103	115	127	139	156	175	211	359	
1	Ayeyarwaddy	0	7,068	7,525	4,785	3,551	948	1,365	2,266	2,070	635	1,112	0	700	211	5,026	37,262
2	Bago	0	3,813	1,462	4,400	1,005	79	1,729	309	1,380	254	417	312	700	0	1,795	17,655
3	Yangon	0	3,937	946	1,155	402	79	1,547	206	575	0	139	0	350	0	2,872	12,208
4	Sagaing	24	620	1,849	2,695	402	0	0	0	115	0	0	0	0	0	0	5,705
5	Mon	24	2,015	301	385	603	0	728	309	0	127	139	0	175	0	0	4,806
6	Mandalay	48	1,798	215	440	268	0	273	0	0	0	0	0	0	0	0	3,042
7	Kachin	168	372	43	55	201	0	0	0	0	0	0	0	0	0	0	839
8	Magway	0	279	172	770	134	0	0	0	0	0	0	0	0	0	0	1,355
9	Tanintharyi	0	465	43	55	0	0	0	0	0	0	0	0	0	0	0	563
10	Rakhine	12	465	0	275	0	0	91	0	0	0	0	0	525	0	0	1,368
11	Kayah	0	62	172	110	0	0	0	0	0	0	0	0	0	0	0	344
12	Shan	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
	Total	336	20,894	12,728	15,125	6,566	1,106	5,733	3,090	4,140	1,016	1,807	312	2,450	211	9,693	85,207

Source: JICA Study Team.

Note: The power outputs were estimated with an assumed plant factor of 0.25 equivalent to 6 hour operation a day (6:00 p.m. to 11:00 p.m. at full output, plus some low load operation during daytime).

Briquette Production from Husk Ash of Gasifier

The unit gas volume produced through imperfect combustion (pyrolysis, thermal decomposition) of rice husks in the gasifier will be about 1 m^3 per kg of rice husk. The combustion energy of this gas is 1,000-1,300 kcal/m^3 (gasification efficiency is 30-33%).

It is a common practice to set the low position calorific value of the rice husk at 3,000 kcal/kg in the planning of steam turbine power generation. Most of the difference of the calorific values between the imperfect combustion (1,000-1,300 kcal/kg) and combustion (3,000 kcal/kg) is left inside husk ash as the fixed carbon.

The Agriculture Mechanization Research Institute of Japan had the experimental production of charcoal briquette using the materials of tar collected from the husk gas by dry processing and the husk ash. There would be a potential, through introducing and improving the ash briquette technology in Myanmar, to utilize husk ash as the heat source for cooking etc.

Bagasse

Bagasse production is 1.3 million tonnes per year and available only in 5 to 6 months a year. Storage of bagasse is difficult since it would cause fermentation due to its high content of water. Accordingly, bagasse is not suitable as fuel of independent small power plant for RE.

Most of the bagasse are self-consumed as fuel of boiler for heat and power supply. In some sugar-mills that have surplus bagasse, it is utilized as materials for pulp.

10.3 Solar Potential

Myanmar has the rainy season from June to October and dry season from November to May. It has abundant sunshine. High sunshine continues daily in the Central Dry Zone (CDZ) in particular as shown in Figure 20 and Table 21.

There is no record of direct measurement of sunshine. Since observation records of sunshine hours are available, monthly radiation was estimated applying a conversion formulae to the sunshine hour records.

Yearly Mean Radiation in Myanmar (DOMH:1994-2000)

Source: JICA Study Team

Figure 20 Solar Potential Map of Myanmar

Table 21 Estimated Monthly Radiation in Myanmar

(Unit:$kWh/m^2/day$)

State	Township	Source of Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
[Kachin State]															
	Putao	DOMH[*1/]	-	-	-	-	-	-	-	-	-	-	-	-	
		Mekong PV Seminar[*2/]	4.16	5.10	5.37	5.57	5.31	3.81	3.46	3.45	3.50	3.73	4.18	3.85	4.29
		Meteonorm[*3/]	3.35	4.04	4.42	5.23	5.03	4.53	4.06	4.19	3.77	3.55	3.67	3.32	4.10
	Myitkyina	DOMH (1994-2000)	4.46	4.69	5.05	5.60	5.27	3.77	3.25	3.63	3.89	4.30	4.23	4.24	4.35
		Mekong PV Seminar	4.16	5.05	5.56	5.82	5.48	4.07	3.69	4.18	4.31	4.15	3.83	3.78	4.51
		Meteonorm	4.03	4.82	5.23	5.87	5.61	4.93	4.48	4.48	4.33	4.16	4.30	4.06	4.69
[Sagaing Division]															
	Monywa	DOMH	-	-	-	-	-	-	-	-	-	-	-	-	
		Mekong PV Seminar	4.45	5.62	6.10	6.46	6.09	5.45	4.93	4.66	4.74	4.37	4.10	4.04	5.08
		Meteonorm	4.39	5.21	5.68	6.23	6.19	5.37	4.71	4.65	4.77	4.74	4.73	4.45	5.09
[Shan State]															
	Lashio	DOMH (1994-1998)	4.51	5.05	5.08	5.24	5.59	3.75	3.42	2.95	3.83	3.91	3.60	3.78	4.23
		Mekong PV Seminar	4.45	5.71	6.07	6.07	5.71	4.91	4.34	4.29	4.52	4.23	4.00	3.84	4.85
		Meteonorm	4.48	5.14	5.52	5.93	5.84	5.33	5.16	4.42	4.67	4.55	4.53	4.48	5.01
[Mandalay Division]															
	Mandalay	DOMH (1994-1998)	4.88	5.27	5.50	6.00	5.91	5.33	4.18	3.92	4.45	4.74	4.50	4.25	4.91
		Mekong PV Seminar	4.50	5.65	6.06	6.33	5.97	5.45	4.88	4.64	4.70	4.34	4.07	3.99	5.05
		Meteonorm	4.52	5.21	5.61	6.10	6.06	5.40	5.06	4.48	4.77	4.74	4.70	4.55	5.10
		JMH[*4/]	5.57	6.20	7.22	7.66	6.24	3.97	4.68	4.70	5.42	5.43	5.22	4.83	5.60
	Meiktila	DOMH (1994-1998)	4.75	4.98	5.71	6.27	5.94	5.23	4.59	4.23	4.11	4.77	4.30	4.41	4.94
		Mekong PV Seminar	-	-	-	-	-	-	-	-	-	-	-	-	
		Meteonorm	4.55	5.25	5.61	6.03	6.00	5.43	5.23	4.42	4.77	4.77	4.67	4.58	5.11
[Chin State]															
	Hakha	DOMH (1994-2000)	4.57	4.98	5.30	5.96	5.09	3.63	2.91	2.86	3.21	3.74	3.79	4.09	4.18
		Mekong PV Seminar	-	-	-	-	-	-	-	-	-	-	-	-	
		Meteonorm	4.35	5.18	5.68	6.30	6.23	5.37	4.58	4.68	4.77	4.74	4.77	4.42	5.09
[Rakhine State]															
	Sittwe	DOMH	-	-	-	-	-	-	-	-	-	-	-	-	
		Mekong PV Seminar	4.65	5.68	5.84	6.19	5.42	3.78	3.54	3.73	4.40	4.70	4.29	4.31	4.71
		Meteonorm	4.35	5.18	5.68	6.30	6.23	5.37	4.58	4.68	4.77	4.77	4.77	4.39	5.09
[Kayah State]															
	Loikaw	DOMH (1999-2000)	5.12	5.23	5.57	6.14	4.33	3.79	3.75	3.86	3.91	4.24	4.47	4.77	4.60
		Mekong PV Seminar	5.11	6.38	6.68	6.81	5.83	5.52	5.57	5.25	5.18	4.92	4.93	4.69	5.57
		Meteonorm	4.68	5.29	5.58	5.87	5.87	5.50	5.61	4.26	4.77	4.77	4.60	4.71	5.13
[Bago Div.]															
	Pyay	DOMH	-	-	-	-	-	-	-	-	-	-	-	-	
		Mekong PV Seminar	4.79	5.88	6.11	6.18	5.60	4.45	4.22	4.21	4.56	4.58	4.35	4.28	4.93
		Meteonorm	4.58	5.25	5.61	6.03	6.00	5.47	5.26	4.42	4.80	4.77	4.67	4.61	5.12
[Yangon Div.]															
	Kaba Aye	DOMH (1994-1998)	5.32	5.68	5.94	6.43	4.97	3.46	3.25	3.11	3.72	4.64	4.69	5.08	4.69
		Mekong PV Seminar	4.92	5.77	6.04	6.40	4.92	3.70	3.41	3.50	4.05	4.63	4.52	4.47	4.69
		Meteonorm	4.68	5.25	5.58	5.83	5.81	5.43	5.55	4.29	4.73	4.71	4.57	4.71	5.09
		JMH	5.54	6.40	7.33	7.75	6.72	5.36	5.26	4.89	5.46	4.77	5.08	5.03	5.80
[Ayeyanwady Div.]															
	Pathein	DOMH (1994-1997)	5.71	6.14	6.36	6.97	5.26	3.73	3.72	3.51	4.06	4.75	4.86	5.32	5.03
		Mekong PV Seminar	-	-	-	-	-	-	-	-	-	-	-	-	
		Meteonorm	4.65	5.25	5.61	5.90	5.87	5.43	5.42	4.35	4.73	4.71	4.60	4.68	5.10
		JMH	5.38	6.16	7.29	7.76	7.12	5.98	6.13	5.60	5.47	4.91	5.06	4.92	5.98
[Mon State]															
	Mawlamyine	DOMH (2000)	5.25	5.21	5.51	4.76	3.57		-	-	-	-	-	-	4.86
		Mekong PV Seminar	-	-	-	-	-	-	-	-	-	-	-	-	
		Meteonorm	4.68	5.21	5.58	5.83	5.74	5.37	5.52	4.32	4.70	4.68	4.57	4.71	5.08
[Taninthayi State.]															
	Dawei	DOMH	-	-	-	-	-	-	-	-	-	-	-	-	
		Mekong PV Seminar	5.06	5.82	6.02	6.29	4.85	4.68	3.42	3.33	4.04	4.86	4.94	4.84	4.85
		Meteonorm	4.58	4.96	5.65	5.63	5.29	4.87	4.87	4.58	4.27	4.19	4.47	4.74	4.84
	Kawthoung	DOMH	-	-	-	-	-	-	-	-	-	-	-	-	
		Mekong PV Seminar	5.07	5.52	5.93	6.09	4.71	3.61	3.30	3.27	3.85	4.72	4.70	4.58	4.61
		Meteonorm	4.65	5.07	5.55	5.47	5.06	4.80	4.77	4.68	4.47	4.32	4.37	4.45	4.80

Source *1/: DOMH (1994-1997) *3/: Meteonorm, Switzerland
*2/: Mekong PV Seminar *4/: JMH

10.4 Wind Potential

Yearly mean wind speed records are shown in Figure 21 based on the 7 year records (1994-2000) of the Department of Meteorology and Hydrology (DOMH).

In general, the wind potential in Myanmar is low. There are few wind observatories that have annual mean wind speed of higher than 3 m/s as shown in Table 22. However, significant wind potential is expected locally.

There are places in the hilly area of Chin and Shan States where monthly mean wind speed exceeds 3 m/s.

In the coastal areas South-West Monsoon prevails for 9 months and North-East Trade Wind in the rest 3 months. Sittwe situated in the northern part of the Rakhine State recorded monthly average wind speed of higher than 3 m/s throughout the year.

CDZ surrounding Nyaung Oo in the Mandalay division recorded annual average wind velocity of nearly 3 m/s.

Yearly Mean Wind Speed in Myanmar (DOMH:1994-2000)

Source: JICA Study Team

Figure 21 Yearly Mean Wind Speed in Myanmar

Table 22 Monthly Mean Wind Speed Records in Myanmar

(Unit: m/s)

State/Divisi	Location	Data Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
[Kachin State]															
	Putao	DOMH (1996-1999)*1/	0.22	0.45	0.45	0.67	0.89	0.00	0.45	0.45	0.45	0.15	0.15	0.60	0.41
		Wind Study Report*2/	-	-	-	-	-	-	-	-	-	-	-	-	-
		Meteonorm*3/	1.60	2.00	2.10	2.00	1.80	1.70	1.70	1.40	1.20	1.20	1.30	1.30	1.61
	Myitkyina	DOMH (1994-1998)	0.59	0.88	1.13	1.10	0.80	0.87	0.62	0.57	0.46	0.53	0.57	0.62	0.73
		Wind Study Report (1966-1980)	0.87	1.14	1.42	1.58	1.23	0.98	1.14	0.98	0.87	0.80	0.88	0.88	1.06
		Meteonorm	1.60	1.90	2.00	1.90	1.70	1.70	1.70	1.40	1.20	1.20	1.20	1.30	1.57
[Sagaing Division]															
	Monywa	DOMH (1994-1998)	1.41	1.44	1.34	1.41	1.52	1.73	1.54	1.07	1.05	1.06	1.41	1.35	1.36
		Wind Study Report (1966-1980)	0.76	0.71	0.97	0.91	1.10	1.45	1.49	1.18	0.74	0.65	0.69	0.59	0.94
		Meteonorm	0.60	0.70	0.90	1.20	1.10	0.90	0.90	0.80	0.60	0.60	0.60	0.50	0.78
[Shan State]															
	Lashio	DOMH (1994-1998)	1.17	1.38	1.17	1.31	0.80	0.89	1.08	0.63	0.54	0.17	0.21	0.46	0.82
		Wind Study Report (1965-1980)	0.88	1.22	1.45	1.54	1.49	1.63	1.60	1.26	1.01	0.82	0.67	0.70	1.19
		Meteonorm	1.40	1.70	1.80	1.80	1.60	1.70	1.70	1.40	1.10	1.10	1.10	1.20	1.47
[Mandalay Division]															
	Mandalay	DOMH (1994-1998)	0.34	0.62	1.16	1.29	1.70	1.87	2.08	1.30	0.70	0.39	0.25	0.22	0.99
		Wind Study Report (1968-1980)	0.93	1.23	1.72	1.89	2.14	2.78	2.91	2.29	1.67	1.22	1.01	0.85	1.72
		Meteonorm	0.50	0.70	0.90	1.20	1.10	0.90	0.90	0.80	0.60	0.60	0.50	0.50	0.77
	Meiktila	DOMH (1994-2000)	0.86	1.03	1.51	1.81	2.27	3.28	3.42	2.33	1.39	0.70	0.81	0.87	1.69
		Wind Study Report (1965-1980)	0.65	0.80	1.16	1.72	2.46	3.30	2.65	2.46	1.37	0.74	0.66	0.63	1.55
		Meteonorm	0.40	0.50	0.70	1.00	0.90	0.70	0.70	0.60	0.40	0.40	0.40	0.30	0.58
[Chin State]															
	Hakha	DOMH (1994-1998)	1.63	2.26	2.91	1.94	2.41	1.97	2.27	1.76	1.12	1.10	1.00	1.09	1.79
		Wind Study Report (1966-1980)	-	-	-	-	-	-	-	-	-	-	-	-	-
		Meteonorm	1.10	1.20	1.50	1.80	2.00	1.70	1.50	1.40	1.30	1.00	1.00	1.00	1.38
[Magway Div.]															
	Magway	DOMH (1994-1998)	0.61	0.56	0.71	0.62	0.79	0.97	0.90	0.85	0.80	0.59	0.61	0.71	0.73
		Wind Study Report	-	-	-	-	-	-	-	-	-	-	-	-	-
		Meteonorm	0.50	0.60	0.80	1.10	1.00	0.80	0.80	0.70	0.60	0.50	0.50	0.40	0.69
[Rakhine State]															
	Sittwe	DOMH (1994-1998)	2.85	2.66	2.80	2.95	3.46	3.66	4.00	3.22	3.00	2.40	2.87	2.51	3.03
		Wind Study Report (1965-1980)	1.96	2.45	2.65	2.65	2.82	3.37	3.35	2.86	2.47	2.06	1.77	1.73	2.51
		Meteonorm	0.90	1.00	1.40	1.80	1.90	1.50	1.30	1.30	1.20	0.90	1.00	0.90	1.26
[Kayah State]															
	Loikaw	DOMH (1994-1998)	-	-	-	-	-	-	-	-	-	-	-	-	-
		Wind Study Report (1968-1977)	0.82	0.53	0.88	0.99	1.08	1.18	1.04	0.97	0.88	0.71	0.67	0.63	0.87
		Meteonorm	0.40	0.50	0.70	1.00	0.90	0.70	0.70	0.60	0.40	0.40	0.40	0.30	0.58
[Bago Div.]															
	Pyay	DOMH (1994-1998)	0.41	0.35	0.41	0.33	1.31	0.46	0.40	0.43	0.33	0.30	0.37	0.38	0.46
		Wind Study Report (1964-1977)	1.09	1.13	1.30	1.65	1.74	1.40	1.37	1.22	1.02	0.92	1.25	1.39	1.29
		Meteonorm	0.50	0.70	0.90	1.30	1.10	0.90	0.90	0.80	0.60	0.60	0.60	0.50	0.78
[Yangon Div.]															
	Kaba Aye	DOMH (1994-1998)	1.06	1.12	1.09	1.18	1.31	1.34	1.33	1.06	1.07	1.05	1.28	1.28	1.18
		Wind Study Report (1968-1980)	1.18	1.43	1.65	1.91	1.70	1.50	1.65	1.55	1.22	1.18	1.17	1.29	1.45
		Meteonorm	0.70	0.90	1.20	1.50	1.20	1.00	1.10	1.00	0.70	0.70	0.70	0.70	0.95
[Ayeyanwady Div.]															
	Pathein	DOMH (1994-1998)	0.97	1.19	1.30	1.58	1.39	1.01	0.97	0.78	0.72	0.72	1.35	1.18	1.10
		Wind Study Report (1964-1980)	1.12	1.34	1.68	1.54	1.50	1.31	1.05	1.01	0.86	0.90	1.06	1.05	1.20
		Meteonorm	0.70	0.90	1.30	1.60	1.30	1.10	1.20	1.10	0.80	0.70	0.70	0.70	1.01
[Kayin State]															
	Hpa-an	DOMH (1994-1998)	0.88	0.97	0.99	1.20	1.04	1.06	1.36	1.13	1.04	1.05	0.97	0.81	1.04
		Wind Study Report (1964-1972, 1976-1	1.10	1.16	1.59	1.81	1.76	1.91	1.78	1.51	1.46	1.19	0.97	1.10	1.45
		Meteonorm	0.80	1.00	1.30	1.60	1.30	1.10	1.20	1.20	0.80	0.70	0.80	0.80	1.05
[Mon State]															
	Mawlamyine	DOMH (1994-1998)	1.11	1.03	1.12	0.96	0.92	0.93	1.09	0.84	0.80	0.89	1.30	1.55	1.04
		Wind Study Report (1964-1980)	1.58	1.70	1.85	2.04	1.99	2.10	2.11	1.94	1.68	1.46	1.94	1.89	1.86
		Meteonorm	1.00	1.30	1.80	2.20	1.70	1.50	1.60	1.50	1.10	1.00	1.10	1.10	1.41
[Taninthayi State.]															
	Dawei	DOMH (1994-2000)	0.19	0.54	0.45	0.49	0.45	0.34	0.46	0.44	0.33	0.31	0.52	0.29	0.40
		Wind Study Report (1965-1980)	1.01	0.97	1.06	0.99	1.15	1.12	1.05	1.15	0.89	0.85	1.05	1.26	1.05
		Meteonorm	1.20	1.40	1.70	1.80	1.70	1.80	1.80	1.80	1.40	1.10	1.50	1.50	1.56
	Kawthoung	DOMH (1994-2000)	0.80	0.80	0.58	0.51	0.63	0.82	1.20	1.11	0.75	0.52	0.64	1.37	0.81
		Wind Study Report (1964-1980)	1.74	1.54	1.47	1.36	1.40	1.64	1.51	1.53	1.19	0.89	1.41	1.86	1.46
		Meteonorm	1.70	1.60	1.50	1.40	1.40	1.80	1.60	1.70	1.40	1.00	1.40	1.80	1.53

Source: *1/: DOMH(1994-2000) *3/ :Metronomrm, Swizerland
*2/ :DOMH, Wind Study Report(1964-1980)

11. Strategy for Implementing RE Using Renewable Energy

11.1 Development Targets of RE

A battery lighting system of 4-8 W order in power consumption has been introduced to a significant ratio of the households on commercial basis as Kerosene Lamp Substitute since the First Oil Crisis in 1973. Such being the situation in the rural area of Myanmar, the large scale RE schemes, which will be directly implemented by MEPE as part of the national policy for rural development, should aim at full scale RE with 24 hour supply.

Those small scale RE schemes, which need to be implemented by VECs under guidance and support by MEPE, should aim at home lighting for more than 5 hours a day (06:00 p.m. to 11:00 p.m.).

Draft targets of RE by region and form of energy are proposed below as a material for discussion and scrutinization among the parties and officials concerned:

- To electrify more than 1% (20 VTs.) of the total number of VTs in Shan State and Chin State (2,103) by installing small, mini, micro, *Village Hydros* and Pico hydros in those areas including hilly and mountainous areas or high rainfall regions where hydro-potential is high.
- To electrify more than 1% (140 VTs.) of the total number of village tracts (VT) in the nation (13,792) every year by introducing rice husk (biomass) gas engines into those areas such as villages in the paddy cultivating regions, semi-urbanized towns nearby middle to large scale rice-mills, and areas nearby sawmills that have extra wood chip.
- To electrify more than 1% (6 VTs) of the total VTs in Kachin State (616 VTs) by introduction of solar/wind BCS in those remote and small villages that have little hydro-potential and no extra rice husk or wood chip available for power generation and that cannot expect RE by the grid extension. In these rural electrification, *community center electrification* by SHS should also be introduced to achieve adequate lighting for the school children for book reading and studying by installing several 20 W fluorescent lights in the Community Center.
- With all the three targets above achieved, the level of rural electrification will be improved by 166 VTs or 1.2% per year as shown in Table 23.

If the draft targets above are achieved, a total of about 58,000 households would be electrified every year. With an average household size of six persons, the total beneficiary would be about 0.35 million. The annual capital requirement would be in an order of $15 million per year for about 0.35 million beneficiary or $42 per beneficiary. This unit cost per beneficiary is at a low level owing to the adoption of local technology, maximum use of local resources, and concentration of *Village RE Schemes* on home lighting.

Table 23 Assumed Rates of Rural Electrification and Required Budget Scale

No.	Type	Capacity	House-holds	Price per Scheme	New VT Electri-fied per	Annual Total		
						House-holds	Popu-lation	Amount
			nos.	$ '000	nos./yr	nos.	1,000	$ '000
1	Rice husk gas engine	50 kW	300	40	140	42,000	252	5,600
2	Mini-hydro by MEPE	300 kW	2,000	1,200	5	10,000	60	6,000
	Village Hydro	50 kW	300	100	15	4,500	27	1,500
3	Solar BCS	16 kWp	200	230	6	1,200	7	1,380
Total			-	-	166	57,700	346	14,480

Source: JICA Study Team

Note: Mini-hydro by MEPE is for rural electrification for general use while rice husk gas engine and Village Hydro are for lighting purpose.

Of the RE schemes in Table 23, those rural electrification schemes to be implemented by VEC on a self-help basis are the rice husk gas engine and *Village Hydros* which will require a total budget of $7.1 million every year. The mini hydro schemes (>100 kW) will be implemented by MEPE. The solar BCS schemes could be implemented only when external financial supports are provided.

If a soft loan is provided to cover the capital costs of the *Village RE Schemes* of VEC with repayment period of 3 years and zero interest rate, the repayment, if made in Kyat, would lose 50% in the net value due to the current high inflation rate about 25% per year upon completion of the repayment:

Loss = 3/3 x 25% + 2/3 x 25% + 1/3 x 25% = 50% of the capital costs

With the pace of RE above, it would take around 60 years to achieve a level of rural electrification of 80%. The household electrification level would be significantly lower than the rural electrification level since some villages under one VT could not be electrified by the RE schemes above due to the distance from the central part of VT as well as low level of household income.

The draft targets are the materials for examination and discussion by the officials concerned. An RE speed at double the draft targets should be pursued so that the household electrification ratio will exceed 80% after one generation or 30 year period in the future. The draft targets should be reviewed and revised upward following the economic development of Myanmar as well as inflow of foreign investments and technical and economic assistance.

11.2 Strategies for Promoting RE

The objective of RE is to provide villagers with lighting by substantially improving the low rural (VT) electrification level at 18% as early as possible through introduction of renewable energy into rural areas of Myanmar.

Weaknesses and Strengths of RE Sector in Myanmar

The weaknesses and strengths of the RE sector in Myanmar may be summarized as shown below:

Weaknesses	Strengths
● Limited coverage of the Grid (only central part of the country) and severe shortage of the generation capacity in the Grid that does not, at present, permit RE by the grid extension; ● As many as about 13,800 village tracts are distributed and waiting for RE in wide areas over the country; ● MEPE has to concentrate its human and financial resources to implementation of the generation expansion projects for the Grid on the short term and there is not many remaining and available for RE.	● Local technology of *Village Hydros* and Pico hydros as well as biomass gas engine at low cost level; ● Rich potential of renewable energy: - hydro potential in Shan, Kachin, Chin, Sagaing, etc. - Rice husk in Aeyarwady, Bago, Yangon, Sagaing, etc. - Countrywide potential of solar power. - Potential of wood biomass and wind power depending on site.
● Power tariff does not reflect actual costs.	● There are MEPE and DHP who have long experience of design and construction of hydropower and distribution lines, and new private contractors are growing in the field of hydropower and distribution lines. ● There are experienced and specialized experts and co-ops in Myanmar in the field of RE using renewable energy.

Technical Strategies

In order to substantially improve the rural electrification level as early as possible by overcoming the weaknesses and fully utilizing the strengths above, the two basic strategies are proposed:

- ***Government RE Scheme*s for 24 hr Supply**: MEPE should implement, on the long-term basis, full scale RE for 24 hour supply (not only for lighting but also for cottage industry and commercial demand) in rural areas by developing small hydros (>50 kW) or extending transmission and distribution lines from the Grid (the grid extension).
- ***Village RE Schemes* for Lighting**: Villagers are encouraged to implement low cost and sustainable lighting on a self-help basis.

Villages will first be electrified mainly for lighting by *Village RE Schemes* at low costs utilizing local technology and resources on the short to medium-term, in order to improve the rural electrification level at the fastest speed. These villages will be connected to the Grid on the long-term by the grid extension to realize full scale RE with 24 hour supply as one of the socio-economic infrastructures of the nation.

The two basic strategies above are discussed below for more details:

Government RE Schemes

MEPE should continue implementation of ongoing generation expansion projects in order to mitigate the load shedding in the Grid as well as to acquire the supply capacity for RE by the grid extension. In addition to the Grid reinforcement works, the *Government RE Scheme*s are:

- To realize full scale RE with 24 hour supply by implementing small hydros (>50 kW) in those villages that have large demand for RE on one hand and high potential of hydropower on the other hand; and
- To implement RE by the grid extension towards villages inside and surrounding the Grid when the ongoing generation expansion projects are commissioned one after another, to enable power supply to RE.

Village RE Schemes

Village RE Schemes are:

- To realize home lighting preceding the grid extension that would take tens of years for most of the non-electrified villages;
- To materialize *simplified electrification*, that is, home lighting for 5 hours a day (18:00-23:00) at the minimum;
- To implement on a self-help basis by the villagers with technical support from MEPE and NGO;
- To facilitate low cost lighting affordable to the villagers, if partly supported by the proposed RE Fund, through introduction of local technologies and resources;
- To implement sustainable lighting systems by building *Village Hydros* or Pico hydros in those remote and mountainous villages where hydro potential exists; and
- To implement sustainable lighting systems by installing biomass gas engine in those villages and towns where rice husk or wood chip is available in necessary volume and at affordable costs, preferably free of charge.

With the two strategies above implemented, some villages would still remain non-electrified even after 30 years because of no potential of hydro or rice husk in the village and remote location far from the Grid. To meet the lighting demand in such villages, the third strategy is proposed:

***Social RE Schemes* for Remote and Poor Villages**

MEPE or NGOs should implement battery lighting on a grant basis in those villages that would otherwise not be electrified either by the *Village RE Schemes* or by the *Government RE Scheme*s even after 30 years. The battery lighting will be powered by solar/wind BCS combined with Community Center Lighting by SHS.

Institutional and Organisational Strategy

To establish first a new Section for Rural Electrification (SRE) under the Transmission and Distribution Department of MEPE that will manage RE nationwide. SRE would in future be restructured to an independent Department of MEPE when its tasks for RE have increased to need it;

To entrust implementation of those RE schemes to the self-help of VECs that will electrify each village using *Village Hydros*, rice husk gas engine, etc. under guidance and technical support by SRE and Township Offices of MEPE; and

To establish MOEP Training Center as the place and occasion of capacity building of those staff of MEPE Divisional Offices who shall guide and support implementation of the *Village RE Schemes* with *Village Hydros* and Pico hydro.

11.3 Tactics for RE

Table 24 presents framework for preliminary selection of the form of renewable energy for the target village in the particular region. The framework may be summarized as follows:

- Small hydros are the most suitable in the Shan Plateau, Chin State, Kachin State, Sagaing division, etc.
- Biomass gas engines are the most suitable in those villages and towns wherever necessary volume of rice husk or wood chip is available from rice-mills or sawmills at affordable price or preferably free of charge.
- *Village Hydros* (<50 kW) and Pico hydros (<1 kW) would be suitable for RE in those remote and hilly areas where the distance from the Grid is long but there is hydro potential. If there is no hydro-potential, solar BCS may be employed depending on the availability of external grant assistance. For those villagers who can afford the costs, SHS may be adopted.
- Wind BCS may be suitable for those sites where high wind potential locally prevails.
- It will be necessary for promotion of RE to implement and manage many small scale RE schemes nationwide. Accordingly, it should be entrusted to the self-help of VECs to plan, implement, and O&M of individual RE schemes with the guidance and support from SRE and Township Offices of MEPE, private sector experts, contractors, and NGO.

Table 24 Framework for Preliminary Selection of Form of Renewable Energy

No.	Region	DHP		MEPE and VEC			
		Extension of Distribution Lines from National/Local Grids	Small & mini-hydro	Village Hydro (Micro/Pico)	Solar BCS	Wind BCS	Biomass gas engine
			50-10,000 kW	<50 kW	0.1-3 kW	0.5-3 kW	10-50 kW
1	Mountain Regions	★	★★★★★	★★★★★	★	★★	★★★★★ with rice husk or sawdust
2	Delta and Paddy Cultivating Regions	★	-	★ on irrigation channel	★	★ where wind prevails	★★★★★ with rice husk
3	Coastal Regions	★	★★	★★	★	★★	★★★★★ with rice husk or sawdust
4	Remote and hardly accessible areas	-	★★	★★★	★★★★★	★★	★★★★ with rice husk
5	Urban Areas including Suburbs	★★★★★	-	-	-	-	-

Legend: [shaded box] This pattern means out of scope of the current study.
★ to ★★★★★ Shows level of potential for implementation.
Biogas may be useful for lighting and cooking in those households in the border areas which are scattered in wide areas and, therefore, favor such individual system as for own home use rather than the distribution line-connected RE system.

Source: JICA Study Team

12. Selection Criteria of RE Schemes Proposed

Various people and agencies would propose various RE schemes and would request for support to MEPE Township Offices, Divisional Offices, or directly to MEPE SRE. Before reviewing the many proposals in detail, these should first be checked with the Selection Criteria and unsuitable schemes screened out. The reason of unsuitability should be explained to the proponent of that scheme and relevant advice given.

For example, a diesel powered BCS may be implemented on commercial basis for meeting the demand of villagers. However, it is not suitable as an RE scheme to be implemented by VEC since it does not meet the Government policy to promote RE using renewable energy. In those villages and towns near rice-mills or sawmills, the feasibility of biomass gas engine shall first be studied before planning solar BCS. On the contrary, a biomass engine scheme planned for electrification of a village smaller than 100 households should be subject to a careful review of the repayment of initial capital costs, employment of experienced operators, and viability to cover O&M expenses and replacement costs of engine in particular with the money to be collected monthly from the villagers.

"Selection Criteria" is the pre-qualification of suitability of the RE projects proposed by VECs or prepared by MEPE.

Of the RE projects that have passed through the Selection Criteria, those that VEC has own implementation program and financing facility do not need to go through Prioritisation Criteria. In these cases, all of these projects should be supported with priority in the technical, institutional, and organisational aspects.

Those RE projects that MEPE implements will be the objects of the Prioritisation Criteria. The Prioritisation Criteria are a tool for ranking the projects in priority order, choose projects for allocating budget of MEPE and proposed RE Fund.

Selection Criteria for RE Projects

Appendix-7 presents Selection Criteria for RE projects by small and mini hydros (>50 kW), *Village Hydros* (<50 kW) and Pico hydros (<1 kW), solar-wind BCS, and biomass.

The Selection Criteria for hydros are based on the qualification of technical suitability of the site conditions in view of such features as the hydro-potential depends on site unlike other renewable energy. The Criteria are added with examination for length of distribution lines from the site up to the target village and the village scale.

Selection criteria for solar BCS are, from the viewpoint of rather uniform availability of solar potential nationwide and requirement of external grant assistance, 1) non-availability of other alternative energy, 2) remoteness in location, and 3) small scale of village. If village scale is large and there is rice husk, biomass gas engine is more suitable. If there is wind potential, solar-wind hybrid BCS would be suitable.

Selection criteria for biomass gas engine are 1) location in the paddy cultivating region or nearby rice-mills or sawmills and availability of rice husk or wood chip free of charge or at affordable price, and (2) certain scale of villages that can afford capital costs and O&M expenses.

The Selection Criteria for hydropower aim at pre-qualification of technical suitability of the site conditions. On the other hand, since the technical features of using biomass gas engine and solar/wind BCS are common nationwide, the Selection Criteria of these renewable energy are based on the availability of biomass fuel for gas engine and comparison with other alternative energy for BCS.

13. Prioritisation Criteria for RE Schemes Selected

The priority of RE projects of MEPE will be assessed and judged based on two groups of evaluation items; one concerned with objectives of the RE projects and the other concerned with priority for implementation.

These evaluation items and their importance may differ amongst agencies that will assess and judge the priority. Accordingly, evaluation items concerned with the objectives and priority of RE projects are selected from the assumed viewpoints of central government, local governments, MEPE, foreign aid agency, etc. On the basis of these, the evaluation items concerned with the objectives of RE projects are selected as presented in Table 25 together with respective weights and criteria for Class A (best meets that objective).

Table 25 Evaluation Items Concerned with Objectives of RE Projects

Evaluation Aspects	Evaluation Items	Weight	Conditions for Class A
Level of RE Services	Present level of rural electrification	3	Less than 5%
	Hours of power supply	3	24 hour a day
	Nos. of households to be served	4	More than 5,000 households (for MEPE schemes)
	Seasonal stability of power supply	3	Seasonally stable
Mitigation of Spatial Imbalance	Remoteness of location	2	Assess by State
	Hardly accessible by road	2	More than 10 hour driving distance from Yangon or Mandalay, or inaccessible by car.
Poverty Alleviation	Location in poor States, villages	2	Comprehensive assessment by State on the basis of household income, malnutrition ratio of children, per capita area of paddy field, location in the priority areas for development.
	Needs for water supply by pump	1	High (areas like CDZ or hill where access to water is inconvenient)
Economic Impacts	Potential of industrial and commercial demand	4	Day time demand forecast at more than 50% of the night time lighting demand.
Sub-total		24	

Source: JICA Study Team

The weight is allocated to 25 evaluation items (total of 9 items in Table 25 and 16 items in Table 26) concerned with objectives and priority, with the total being 50. Since the high score for each evaluation item is given point 2, the total points with all Class A assessment will be the full score of point 100.

In Table 25 the evaluation aspect of the Level of RE Services is given 13 points in total weight of its four evaluation items, being the greatest. Since the battery-lighting has been spread to 24% of the rural households of Myanmar, the highest weight is allocated to achieving home lighting with 20 W fluorescent lights for 5 hours a day.

Next, the evaluation items considered important in assessing the priority of RE projects are presented in Table 26 together with respective weights.

Table 26 Evaluation Items Concerned with Priority of RE Projects

Evaluation Aspects	Evaluation Items	Weight	Conditions for Class A
Level of community demand to RE	VEC established	2	VEC exists.
	Willingness to participate in RE promotion	2	highly willing
Lead Time till start power supply	Lead time till commissioning	2	Within 6 month period.
	Easiness in construction works	1	Ordinary civil works (Class A for all schemes other than hydro)
Cost Effectiveness	Length of new access road to site	2	Construction of new access road is not required.
	Length of transmission line from site to village	1	<2 km
	Best use of local technology and resources	2	Class A for biomass gas engine (Class B for solar-wind, and individual assessment for hydro)
	Extra power to be fed to Grid	1	Grid (Class B for local independent power systems)
Environmental Impact	Reduction of CO_2 emission	2	More than 1,000 kW in installed capacity
	Partial substitution of firewood	1	Hydro (Class B for biomass gas engine, Class C for solar-wind)
Sustainability	Simple O&M	2	Solar-wind (Class B for hydro, Class C for biomass gas engine)
	O&M by dependable VEC	2	VEC exists.
	Monitoring system	1	Exists.

Public Relations	PR Potential for SRE, MEPE	1	High (in view of new concept, project scale, effect to socioeconomic development)
	Project visibility for other villagers	2	High (location for non-electrified villagers easy to see)
	Location within the border areas	2	Crop-replaced area within the border areas.
Sub-total		26	
Total		50	

Source: JICA Study Team

As described above, the priority of RE projects will be assessed and judged, based on the two groups of evaluation aspects; those evaluation items concerned with objectives and those concerned with priority of implementation. Since the objectives of these RE projects are common among the four forms of renewable energy, those evaluation items concerned with the objectives are prioritised (ranked with points) by one common criteria. Also, most of the evaluation items concerned with the priority of implementation including willingness of villagers to participate in RE promotion are common items independent from the form of renewable energy and, therefore, can be assessed by the common criteria. Those evaluation items which assessment may differ by the form of renewable energy are item No. 19 substitution effect of firewood and item No. 20 simplicity in O&M (refer to Table 27 for item No.). These items among the different forms of renewable energy can be technically assessed.

As a conclusion, the priority of the RE projects using renewable energy can be assessed by one common criteria among the four forms of renewable energy. Table 27 presents criteria for ranking into three classes (with points 2, 1, and 0) for all the 25 evaluation items. Table 28 lists the priority development projects which have been prioritised as Classes A and B from among those projects formulated and proposed so far in the Study.

The priority classes A, B, and C are defined as follows:

A: **Top priority projects with total score greater than 70**

B: Priority project with total score greater than 60

C: Prospective projects in the future, with total score lower than 60.

Table 27 Prioritisation Criteria

Evaluation Aspects	Evaluation Parameters	No.	Wei-ght	Unit	Points for Prioritisation 2	1	0	Full Score
Perceived Objectives of Agencies								
Level of RE Services	Present ratio of electrification	1	3	%	< 5	< 20	> 20	6
	Level of RE services planned	2	3	-	24 hr/day	3-5 hr/day	8 W light	6
	Nos. of households to be served	3	4	h.h.	> 5,000	> 500	< 500	8
	Seasonal stability of power supply	4	3	-	stable	minor fluctuation	significant drops	6
Mitigation of Spatial Imbalance	Remoteness of location	5	2	-	see Note 1			4
	Hardly accessible by road	6	2	hr	> 10	> 5	< 5	4
Poverty Alleviation	Location in poor States, villages	7	2	-	see Note 2			4
	Needs for water supply by pump	8	1	-	high needs	needs	nil	2
Economic Impacts	Potential of industrial and commercial demand	9	4	-	high demand (> 50%)	demand (> 10%)	nil (< 10%)	8
Perceived Requirements of Agencies								
Status of Community	VEA established	10	2	-	exists	in preparation	nil	4
	Willingness to participate in RE promotion	11	2	-	highly willing	willing	nil	4
Lead Time	Lead time till commissioning	12	2	yr	< 0.5	< 2.0	> 2.0	4
	Easiness in construction works	13	1	-	-	difficult	very difficult	2
Cost Effectiveness	Length of new access road to site	14	2	km	nil	< 2.0	> 2.0	4
	Length of transmission line from site to village	15	1	km	< 2.0	< 10.0	> 10.0	2
	Best use of local technology and resources	16	2	-	highly employed	employed	nil	4
	Extra power to be fed to Grid	17	1	-	Main Grid connected	local grid connected	nil	2
Environmental Impact	Reduction of CO_2 emission	18	2	kW	> 1,000	> 30	< 30	4
	Partial substitution of firewood	19	1	-	hydro	gas engine	solar, wind	2
Sustainability	Simple O&M	20	2	-	solar, wind	hydro	gas engine	4
	O&M by dependable VEA	21	2	-	VEA exists	in preparation	not yet	4
	Monitoring system	22	1	-	exists	in preparation	not yet	2
Public Relations	PR Potential for RE agency	23	1	-	high	medium	nil	2
	Project visibility for other villagers	24	2	-	high	medium	nil	4
	Border areas	25	2	-	crop-replaced	Border areas	other areas	4
Total Score			50					100
Priority by Score								
Priority Group								

No.	SH-01 Inle Hydro		SH-02 Nam Lan Hydro		SH-03 Parhe Hydro		SH-04 Nam Kone Hydro		SH-05 Maing Pying Hydro		SH-06 Ganga W Hydro		SH-07 Dawai Hydro		SH-08 Ngot C. Hydro	
1	2	6	1	3	1	3	1	3	1	3	1	3	1	3	2	6
2	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6
3	2	8	1	4	1	4	1	4	1	4	1	4	2	8	1	4
4	2	6	2	6	2	6	1	3	1	3	1	3	2	6	1	3
5	2	4	2	4	1	2	2	4	2	4	2	4	2	4	2	4
6	1	2	1	2	1	2	2	4	2	4	2	4	2	4	2	4
7	2	4	2	4	2	4	2	4	2	4	2	4	1	2	2	4
8	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0
9	2	8	2	8	1	4	1	4	1	4	2	8	2	8	0	0
10	1	2	1	2	1	2	1	2	1	2	2	4	0	0	0	0
11	1	2	1	2	1	2	1	2	2	4	2	4	1	2	0	0
12	1	2	1	2	1	2	1	2	1	2	1	2	0	0	0	0
13	1	1	2	2	2	2	2	2	2	2	2	2	1	1	1	1
14	1	2	2	4	2	4	2	4	1	2	1	2	0	0	0	0
15	1	1	2	2	2	2	1	1	1	1	1	1	0	0	1	1
16	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4
17	2	2	2	2	1	1	0	0	1	1	1	1	1	1	1	1
18	2	4	1	2	1	2	1	2	1	2	2	4	2	4	1	2
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
21	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
23	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
24	2	4	1	2	1	2	1	2	1	2	1	2	1	2	1	2
25	0	0	1	2	0	0	1	2	1	2	1	2	0	0	0	0
Total Score	81		76		66		67		67		76		67		53	
Priority by Score	1		2		12		9		9		2		9		15	
Priority Group	A		A		B		B		B		A		B		C	

No.	SH-09 Nam Kung Hydro		RH-20 Rehab. Hydro		BM-01 Model Husk Vil.		BM-02 Rice Husk RE		BM-03 Husk Gas + BCS		BM-04 Diesel Substitute		SW-01 SW BCS Kachin		SW-02 Wind BCS Magwe	
1	0	0	1	3	2	6	2	6	2	6	1	3	2	6	2	6
2	2	6	2	6	2	6	1	3	1	3	1	3	1	3	1	3
3	1	4	2	8	1	4	2	8	1	4	2	8	0	0	0	0
4	2	6	1	3	2	6	2	6	2	6	2	6	2	6	2	6
5	0	0	2	4	0	0	1	2	2	4	2	4	2	4	1	2
6	0	0	2	4	0	0	1	2	2	4	1	2	2	4	1	2
7	0	0	2	4	2	4	2	4	2	4	1	2	2	4	2	4
8	0	0	0	0	2	2	1	1	1	1	1	1	1	1	1	1
9	1	4	2	8	2	8	1	4	1	4	2	8	0	0	0	0
10	2	4	0	0	1	2	1	2	1	2	0	0	1	2	1	2
11	2	4	0	0	2	4	2	4	1	2	0	0	2	4	2	4
12	0	0	2	4	2	4	2	4	2	4	2	4	2	4	2	4
13	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	0	0	2	4	2	4	2	4	2	4	2	4	2	4	2	4
15	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	2	4	1	2	2	4	2	4	2	4	2	4	2	4	2	4
17	1	1	2	2	0	0	0	0	0	0	1	1	0	0	0	0
18	2	4	2	4	1	2	1	2	1	2	2	4	0	0	0	0
19	2	2	2	2	1	1	1	1	1	1	1	1	0	0	0	0
20	1	2	1	2	0	0	1	2	1	2	0	0	2	4	2	4
21	2	4	2	4	2	4	1	2	1	2	2	4	2	4	2	4
22	2	2	2	2	2	2	1	1	1	1	2	2	2	2	2	2
23	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
24	1	2	1	2	2	4	1	2	1	2	2	4	1	2	2	4
25	1	2	1	2	0	0	0	0	1	2	1	2	1	2	0	0
Total Score	53		75		73		70		70		73		66		62	
Priority by Score	15		4		5		7		7		5		12		14	
Priority Group	C		A		A		B		B		A		B		B	

Note 1 on Remoteness: Point 2 for Kachine, Sagaing, Shan, Kayah, Chin, Rakhine, Kayin, Thanintharyi; Point 1 for Magway, Ayeyawady, Bago, Mon,; No point for Yangon, Mandalay.

Note 2 on Poverty: Point 2 for Kachine, Chin, Rakhine, Magway, Sagaing, Kayah; Point 1 for Shan, Ayeyawady, Bago, Mon, Kayin, Thanintharyi; No point for Yangon, Mandalay.

Source: JICA Study Team

Table 28 List of Priority Development Projects

SH-series Rural Electrification Projects with Small and Mini-hydro

- <u>SH-01 The Inle Lakeshore Rural Electrification Project in Southern Shan</u>
- <u>SH-02 The Nam Lan Rural Electrification Project in Northern Shan</u>
- *SH-03 The Parhe Rural Electrification Project in Northern Shan*
- SH-04 The Nam Kone Chaung Rural Electrification Project in Northern Shan
- *SH-05 The Maing Pying Rural Electrification Project in Eastern Shan*
- <u>SH-06 The Gangaw Rural Electrification Project in Magway Division</u>
- *SH-07 The Dawai Rural Electrification Project in Thanintharyi Division*

<u>RH-01 The Rehabilitation Project of Small Hydropower Stations in Myanmar</u>

<u>CB-01 MEPE Capacity Building Project</u>

BM-series Biomass Gas Engine Rural Electrification Projects

- <u>BM-01 The Model Villages for Rural Electrification with Rice Husk Gas Engine and Solar BCS</u>
- BM-02 The Project for Promotion of Rural Electrification with Rice Husk Gas Engine (Prospective regions: Ayeyarwady Division, Bago Division, Yangon Division, Sagaing Division, Magway Division, Mandalay Division, etc.)
- *BM-03 The Project for Promotion of Rural Electrification with Rice Husk Gas Engine and Solar-Wind BCS (Prospective regions: Kachin State, Rakhaine State, etc.)*
- <u>BM-04 The Pilot Project for Diesel Substitute of MEPE Power Plants for Rural Electrification</u>

SW-series Solar-Wind BCS Rural Electrification Projects

- *SW-01 The Project for Promotion of Rural Electrification with Solar-Wind BCS in Kachin State*
- *SW-02 The Project for Promotion of Rural Electrification with Wind BCS in Magwe Division*

Note: Those projects underlined are Priority A Projects and in Italic Priority B Projects.

Source: JICA Study Team

14. Technical Standards for RE

14.1 Data Necessary for Basic Planning

Visual Guide is prepared by summarizing the Guidelines for quick references and initial data collection by villagers. A form for data collection is also attached to Visual Guide of respective form of energy.

(1) Small Hydropower

In order to formulate development idea and plan of *Village Hydros* (<50 kW) for rural electrification, collection of the following data will be needed:

Number of households in the target village for electrification; availability of access road from public road nearby to the village; distance to the nearest distribution lines of MEPE; a list of public facilities, cottage industries, and commercial facilities which will need daytime supply of power.

In relation to the candidate hydro potential site, the discharge (= run-of-the-river = runoff = water flowing in the river, usually expressed in cubic meters per second or m^3/s) at the end of the dry season (April to May, the timing may slightly change from year to year), head available for power generation (height difference between the intake point and tailrace point, measured and expressed in m), and availability of access road from the village.

(2) Biomass Gas Engine

In order to prepare basic plan of rural electrification by rice husk gas engine, the following data should be collected:

Number of households in the target village for electrification; availability of access road from public road nearby to the village; distance to the nearest distribution lines of MEPE; a list of public facilities, cottage industries, and commercial facilities which will need daytime supply of power.

The volume of rice husk produced from the rice-mills existing in the villages or nearby, present use of the rice husk, the volume of the rice husk available for the power generation, and information on large scale rice-mills located nearby and if there is extra rice husk. (It is important to locate the rice husk gas engine beside the main rice-mill existing in the village. Transportation of rice husk over long distance shall be avoided since it will be costly due to requirement of a large truck for the low specific weight of husk at about 0.1).

(3) Solar/Wind Power

In order to work out basic plan of RE schemes with solar/wind BCS or SHS, the following data should be collected:

- Number of households in the target village for electrification; a list of public facilities; and
- An interview survey will be needed on the electric appliances the villagers wish to use, in order to estimate the power demand. The power supply capacity should be determined with reference to both the power demand of

the villagers (including forecast increase over some 5 years) and the Ability to Pay of the villagers.

Appendix-9 presents Forms for Interview Survey and Planning for each household.

14.2 Equipment and Facilities of Power Supply Systems

(1) Small Hydropower

The small hydros (>50 kW) by MEPE should be planned and designed in accordance with Design Criteria of the Department of Hydroelectric Power (DHP) of MOEP.

The *Village Hydros* (<50 kW) should be planned and designed with reference to the Design Manual-Village Hydros prepared as part of the Study.

The Pico hydros (<1 kW) may be planned and installed in accordance with specifications of manufacturers of turbine-generator.

(2) Biomass Gas Engine

Although there were examples tackled prosperously with biomass gas engine in China and Thailand, the removal of the tar from the gas produced from rice husks by pyrolysis was difficult. Accordingly, an application to fuel substitute of engine had not been successfully practiced.

In recent years, a cooperative named Myanmar Inventors Cooperative Ltd. (MIC) succeeded in overcoming the issue and started commercial production of the gasification and engine-generator system since 1995. A total of 109 units and 8,280 HP in total capacity of husk engine were installed to 2000. These are mostly being used to power rice-mills.

In 2001 there were purchase orders to MIC for 52 units from Ayeyarwaddy division and 21 units from Kachin State.

The husk combustion chamber and filtering devices of the gas are all locally made. They remodel second-hand diesel engines of trucks to the spark plug ignition system. Supply of spare parts for aged engines would be an issue.

The cost of this rice husk gasification engine generator set is low. No special expenses are required for water treatment, unlike the steam turbine generator. However, it should be noted that the distribution line costs would cost more than the gasifier-generator sets.

The product list of MIC is shown in Table 29.

According to the test carried out in Japan (Agriculture Mechanization Research Institute), it required 3-5 kg of rice husk per kWh. It was reported at 2.0-2.2 kg/kWh in China.

It is necessary to measure and confirm the actual relationship between the fuel consumption rate and power generation of the MIC unit.

In Table 29, it was simply assumed that the normal generator output would be 30% of the engine capacity. MIC has a plan to measure these net output and unit husk consumption more accurately in late 2003. Upon completion of the measurements, these figures should be reviewed and revised as appropriate.

Table 29 Features of Rice Husk Gas Engine Generator of MIC

Model	Engine Capacity Pe	Price		Rice husk consumption		Normal Generator Output Pg	Price per Pg	Unit Husk Consumption per Pg
	kW	million Kyat	US$	Basket per hour	kg	kW	US$/kW	kg/kW
RH-3	20	1.077	3,100	4	20.0	6	520	3.3
RH-4	25	1.297	3,700	5	25.0	8	460	3.1
RH-5	35	1.517	4,300	6	30.0	11	390	2.7
RH-6	40	1.687	4,800	7	35.0	12	400	2.9
RH-7	50	1.857	5,300	8	40.0	15	350	2.7
RH-8	60	2.027	5,800	9	44.9	18	320	2.5
RH-10	75	2.707	7,700	12	59.9	23	330	2.6
RH-14	120	4.707	13,400	16	79.9	36	370	2.2
RH-20	160	5.807	16,600	24	119.9	48	350	2.5

Note: Exchange rate was assumed at Kyat 350/US$ in early 2001.
1 Basket of husk = 11 pound = 5.0 kg
Normal generator output was tentatively assumed at 30% of the engine capacity.
Source: MIC for engine capacity, price, rice husk consumption in busket.
JICA Study Team for assumed Pg, price per Pg, unit consumption per Pg.

Tar is included in the gas produced from rice husk by pylorysis. Without sufficient removal of the tar, it may cause engine troubles. It is very important to clean the system everyday such as removal of tar collected in the gas-trap, replacement of the rice husk filters, etc.

The unit gas production per rice husk depends on the moisture content of husk. The higher moisture content the less unit gas production due to the energy consumption for moisture vaporizing. Therefore, the rice husk should be stored in a dry place with roofing and walling against rain.

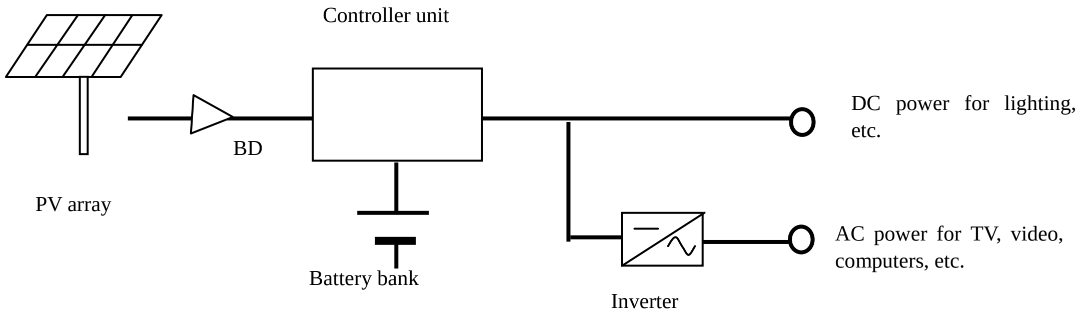
The gasifier and engine shall be placed in a building which permits natural ventilation in order to avoid incidents due to gases leaked, exhausted and accumulated inside the building.

The production capacity of the Myanmar Inventors Cooperative is 7 sets per month each at Yangon and Pathein factories, i.e., 14 sets in total per month.

The distribution lines can be planned and designed with reference to the Design Manual-Village Hydros in Vol. 4 in consultation with the MEPE Township Office covering the village of interest.

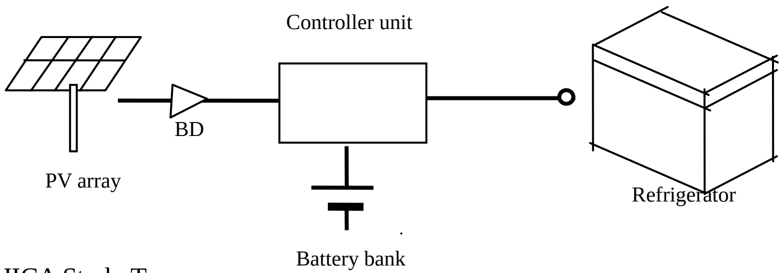
(3) Solar Power

Various application of SHS to RE is possible. Figures 22 to 25 illustrates system configuration of these SHS variations.



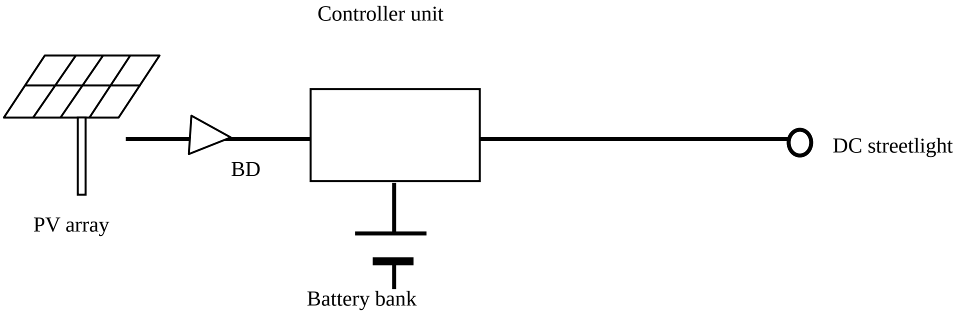
Source: JICA Study Team

Figure 22 SHS for Home, Schools, Hospitals, Community Centers, etc.



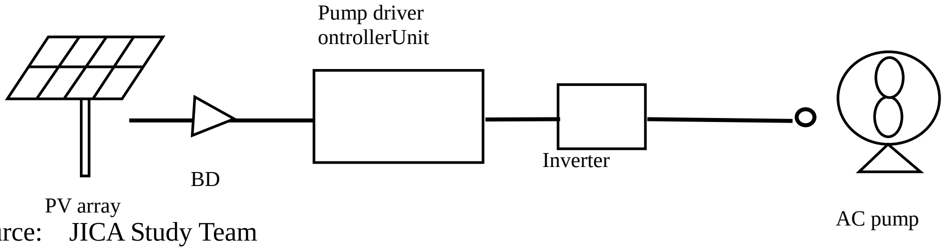
Source: JICA Study Team

Figure 23 PV for Vaccine Storage



Source: JICA Study Team

Figure 24 PV for Streetlights



Source: JICA Study Team

Figure 25 PV for Water Pumping

Possible application systems of solar and wind power are summarized in Table 30.

Table 31 presents sample capacity of PV panel of SHS, daily energy output by weather, and possible operation hour/day of typical lighting and radio.

In order to mobilize the technology and experience accumulated through the many BCSs widely introduced in Myanmar, the RE schemes with solar PV should be of BCS type in principle.

However, if it is financially possible on an individual basis, electrification of household by SHS should also be pursued.

Among the public facilities, monasteries require a significant amount of electric power compared with the household demand. In particular when the demand exceeds 1 kWh/day, SHS is desirable. A study on SHS will be required also for schools, community centers, clinics, and so forth.

Using the Planning Sheets given in Appendices-10 and 11, necessary capacity of solar PV panels should be estimated for BCS and SHS for public facilities, using the electric demand survey results.

Table 30 Electrification Systems by Solar-Wind Power

Household electrification	SHS	SHS consists of PV panels, a battery bank, and controlling units and is installed at the demand site for direct power supply through in-house wiring. All of the system for home electrification should be owned and maintained privately at user’s own expenses.
	BCS	PV array (set of PV panels) is installed at BCS while users have their own batteries that are charged regularly at BCS. Batteries, in-house wiring, and electric appliances should be owned and maintained privately at user’s own expenses, while PV panels to BCS should be jointly owned and maintained by VEC.
Electrification of public facilities	Street Lighting System	The system configuration is the same with that of SHS. The capacity is smaller compared to SHS for household.
	Community Center	The system configuration is the same with that of SHS. The capacity is larger compared to SHS for household.
	Clinic	
	School	
	Potable Water	This is not lighting but supplies power to a water pump. It has no battery bank. A water tank will function as energy reservoir instead of a battery bank.

Source: JICA Study Team

Table 31   PV Panel Capacity and Expected Energy Output

Capacity of PV Panel	Size of Power Output (Wh/day)			Operation Hours (Hours)		
	Dry Season	Mean	Rainy Season	Lamp (20W)	Radio Cassette (5W)	Others
50 Wp	95	80	65	1set x 3	1set x 1	
100 Wp	190	160	130	1set x 5	1set x 5	
200 Wp	380	320	260	2sets x 5	1set x 10	(TV)
300 Wp	570	480	390	3sets x 5	1set x 10	TV

Source: Estimated by JICA Study Team based on the Irradiation Data at Myityina, DOMH.

As for the management of BCS and battery recycling shop, it will be important for achieving a sustainable operation to select suitable operators and set the battery charging fee at appropriate level.

(4) Wind Power

Since wind speed data at candidate sites are usually not available, the following method of implementation are desirable:

- Measure wind speed at the candidate site with portable wind speed meter, each measurement for 10 minutes average speed.   The measurement shall be made at as much high place as possible above ground, to get higher wind speed.   Measure every one hour for 24 hours.   Compare these data with the long-term wind records of observatory of DOMH nearby, and preliminarily judge the potential.
- If there is a financial measure, install a Pico wind plant of 100s W scale for use as power source of small BCS and wind speed observatory for 1-2 years. Judge the potential.
- Implement a full scale development of wind powered RE.

It is recommended that the source of power for public facilities be planned with solar PV panels.   A study will be needed on a solar PV-wind turbine hybrid system to pool excess power between the PV system installed at the public facilities and wind BCSs installed for home lighting.

Using the Planning Sheets given in Appendixes-10 and 12, necessary numbers and capacity of wind turbine generators should be estimated based on the household demand in the villages surveyed.

With respect to the other aspects, those descriptions for solar power above can be applied.

14.3 Assessment of Feasibility

(1) Small Hydropower

Compared to medium to large scale hydropower, which costs $2,000/kW on an average, the *Village Hydros* (<50 kW) suitable for rural electrification has small scale demerit and will in general be costly. However, it would have economic feasibility comparable or superior to the medium to large scale hydropower if the costs for transmission lines required for an alternative by the grid extension are taken into account as part of the economic benefit in addition to the relevant generation costs of the Grid.

Those *Village Hydros* developed and installed by a private sector expert in Taunggyi have achieved a cost level in an order of $600/kW of generator capacity (unit cost per net kW consumed at household may be significantly higher) with the following measures:

- Earth works, concreting works, building works, quarrying and production of gravel, timber poles for distribution lines, etc. are executed on the villagers' contribution basis.
- Generating equipment and metal works (gates, penstock) are mostly manufactured and assembled by the local expert except for import of some components like generators, wires and insulators for distribution lines.
- The turbine output is controlled by adjusting turbine discharge with guidevane and intake gate.
- Distribution lines are with local timbers, which require yearly inspection and replacement of some supports, and minimum size conductors that can marginally carry power. (The conductor size should be selected with reference to Design Manual-Village Hydro in Vol. 4.)

As shown in Appendix-1, these *Village Hydros* have been in operation for more than 10 years to prove technical dependability. The economic feasibility may be apparent if the unit cost (>$600 per net kW) is compared with average cost at $2,000/kW of the medium to large hydros.

Since there is no extra power in the Grid and local independent power systems that can be allocated to RE, the RE by the grid extension can be started only after 2005 when the ongoing hydropower expansion projects with a total installed capacity of 2,000 MW are put into operation one after another. It means the benefit of alternative RE plan by the grid extension can be accounted for only from 2006 at the earliest. This time delay in the benefit of alternative plan increases the benefit of the RE by *Village Hydros*.

In the case of rural electrification by MEPE (*Government RE Schemes*), the generating equipment and distribution facility will be designed to meet the evening peak load for lighting. The plant factor will be low making the system costs relatively high compared with the Grid power stations. However, in the case of schemes which has sufficient daytime load comparable to the night time lighting demand like in Nam Lan Scheme in Northern Shan, the plant factor will be improved and economic feasibility as well.

The economic benefit may be assessed by WTP which is $1 to 2 (K520-750 in 2001) per month for monthly payments and $18 (K10,000 in 2001) per household for initial capital costs.

Financial balance of *Village RE Schemes* can be assessed by ATP or with reference to the actual monthly charge collected in the existing electrified villages. The monthly charges of various existing schemes were about $1.0 per month (K400-600) in early 2001 for households using 1-2 nos. of 20 W fluorescent lamps. The initial capital costs allocated to each household depending on the income level were $40-80 (K20,000-40,000) in 2001. ATP in one year is about $80 as the average household saving.

In the case of Pico hydro (<1 kW), the affordability to pay for the initial capital costs by individual or household group will control the materialization of the scheme. The market prices of China-made turbine-generator sets were in an order as shown in Table 32. Accordingly, if the installation works of the channel for the turbine and erection works of the distribution lines are made free of charge by the villagers contribution, the cash expenses could be managed within the affordable capital costs of $40-80 per household.

Table 32 Market Price of China-Made Turbine-Generator Set

Label Capa-city of Turbine	Assumed Net Output	Market Price in Yangon as of Sept. 2001		Unit Price per	
				Output	Household
kW	kW	Kyat	US$	US$/kW	US$/0.1 kW
0.3	0.15	30,000	60	400	40
0.5	0.25	33,600	67	270	27
0.6	0.30	50,400	101	340	34
1.0	0.50	67,200	134	270	27
1.5	0.75	84,000	168	220	22
2.0	1.00	100,800	202	200	20

Source: Market survey by JICA Study Team

The Pico hydro above may have the issue: wiring works including in-house wiring should use adequate size of conductors and insulators since current leakage and short circuiting may cause fire and accidents.

Another point to assess the feasibility of small hydropower is the fact it is renewable. The Grid is consuming fossil fuels at the least rate of 0.0016 bbl of crude oil equivalent per kWh generation (1999-2000, at a standard thermal efficiency of 38%, the unit oil consumption is; 860 kcal/kWh / 0.38 / 9,250 kcal/l of oil / 159 l/bbl = 0.0016 bbl/kWh). Thus, an electricity consumption of 50 kWh/h.h./month (600 kWh/h.h./year), for example, consumes about one bbl of crude oil per household annually (= 0.0016 bbl/kWh x 600 kWh = 0.96 bbl of oil. $20/bbl x 0.0016 bbl/kWh = $0.03/kWh). This means, assuming an international crude oil price at $20/bbl, such scheme has an economic benefit of $20/h.h./year as the fuel costs of thermal plants in the Grid. In addition, capacity costs of the thermal plants and long transmission lines can also be regarded as economic benefit of RE.

Therefore, RE by small hydros including *Village Hydros* will have significant benefits for the Myanma economy.

(2) Biomass Gas Engine

Biomass gas engine, especially the rice husk gas engine, is the home made technology of Myanmar and is one of the most affordable for the villages.

The rice husk gas engine can supply electricity for lighting at about 80 W per household. The use of electricity should be limited to lighting and some electric appliances of small power consumption for 5 hours from 18:00 to 23:00.

The initial investment cost is relatively low compared to small and mini-hydropower (>100 kW) that facilitates full scale RE for 24 hours. The operation and management costs depend on the husk price. Although local participation in construction work and operation and maintenance will reduce the costs for building, storage, etc., the initial cost is roughly $130 per household, of which distribution lines costs share more than 50%.

For a community, where the initial cost of $80/h.h. is within the affordable range, biomass gas engine is a feasible option for a community-initiated RE. For an average family, the cost would be too large to pay at once. It would take a few years to complete the payment.

Because of the high rate of inflation the amount of repayment in Kyat would be increased year by year depending on the terms and conditions of the loan provided. In addition the agricultural income is sensitive to weather and the income cannot be so stable as of the urban employees. These factors make rural residents difficult to pay regularly. In this context, if the cost $80/h.h. is beyond the Ability to Pay, saving of household income for a few years will be required and an external support will be needed and effective.

(3) Solar and Wind BCS

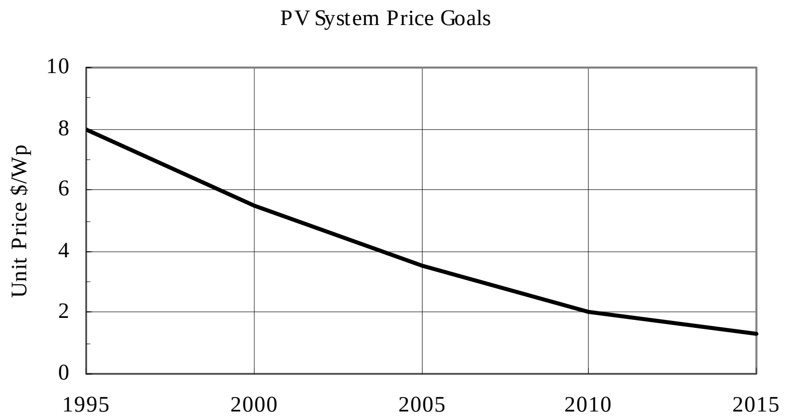
The costs required for alternative diesel engine can be regarded as economic benefit of the RE scheme with solar-wind BCS. For example, diesel oil is air-transported to Putao township, Kachin State. It cost K1,200 per gallon in February 2001. In spite of this high price of diesel, several small scale diesel generators were observed in the region. The diesel generators were introduced owing to their low initial costs that make diesel generator easy to access. While the high initial cost of solar-wind BCS is the main barrier for introduction.

Unless special soft loan for RE is available for the villagers in such remote areas where no other form of renewable energy is feasible, solar-wind BCS could be introduced only with external financial support for its capital costs. The batteries and lights should be at the expense of the villagers, to secure sustainability.

For example, the total initial cost of BCS of a village of 120 households in Meiktilar district was about $7,600 ($63/h.h.) and this cost was shared by local donors. The cost shares of solar panel, batteries and others are respectively 55%, 12%, and 35%. The operation and maintenance have to be sustained by the villagers (or VEC).

The operation and maintenance costs are those of batteries, which include battery charging fee (in local market it was about K10-30 in 2001, once in 4-5 days) and battery recycling cost (about K1,500-2,000 in every 6 months). In this regard, the market of battery parts, repairing and recycling is important, especially for a remote village having difficult or no road access in the rainy season.

The technological advances of solar PV cell are rapid and the cost and the sales price of solar panel are decreasing year by year. Figure 26 shows a scenario of future PV panel price in $/Wp. The current price of $4-5/Wp is targeted to be lowered to $2 (a half of present price) by 2010. Ultimately, it is expected to be less than 1 $/Wp in the future beyond 2015.



Source: DOE, USA, 1998

Figure 26 PV System Price Goals

(4) Wind Power

The wind power equipment as source of BCS will have a capacity of 1-5 kW. This scale of windmill is maintenance free. However, after 3-4 years of operation, inspection by expert will be required.

The issue is to procure necessary spare parts and tools upon the initial procurement and to have training for O&M.

Participation of local wind experts is essential and contributes to periodical inspection and training of O&M.

14.4 Environmental Impacts

(1) Small Hydropower

The environmental impacts expected in general to accompany those small hydropower projects except for Pico hydro are as listed below:

The impacts of the river water to be reduced in the river section between the intake point (water taking point from the river to the channel of the hydro scheme) and the outfall point (water returning point back to the river) on the social and natural environments including bio-diversity and aquatic habitat

The impacts of the power water on the existing water use such as domestic, irrigation, waterwheels.

The impacts of the rising river water levels accompanying peak power generation in the evenings in particular on the children along the river bank.

(2) Biomass Gas Engine

The disposal of the ash and cooling/filtering water is environmental issues of the husk gasifier. In the present gasification system of MIC, the ash is discharged into water which was used for the purification of gas. Some farmers take the ash as fertilizer but the wastewater is left draining. The effluence of the black wastewater including ash causes an environmental problem.

Engine noise and exhaust gas may have some adverse impacts when installed within urbanized township. The location should be selected with due consideration to these aspects and explanation to the neighbourers.

Care is required to prevent operators from breathing leaked gas and/or exhaust gas. Protection cover should be provided to avoid touching rotating belts, etc. of the engine-generator.

There is a risk of fire in the rice husk storage.

(3) Solar Power and Wind Power

Disposal of electrolyte, which will be wasted at the time of recycling the battery, is an issue of BCS. It is recommendable that electrolyte be treated with lime before disposal.

The location of wind turbine should be selected taking into consideration the noise of wind-blades.

15. Database for Introduction of Renewable Energies

15.1 Database for Introduction of Renewable Energies

In a general sense, a database is a system containing a large amount of information and data which is systematically organized. The data are stored in computer files on PC or CD-ROM.

The Database is jointly established by the JICA Study Team and MEPE Counterpart Team. The Database will be used, updated and maintained by MEPE.

15.2 Contents

The Database consists of four parts as shown below:

Item	Title	Description
Part 1	Village Database	Database of rural areas in Myanmar such as township and village information, statistic data, and maps
Part 2	Power Potential Database	Database of potential of renewable energy covering hydro, biomass, solar, and wind power
Part 3	RE Project Database	Rural electrification project database for project formulation, planning, and operation and maintenance
Part 4	Technical Information Database	Database of technical reference that would be useful for rural electrification

Part 1 includes general data that would be referred to in the planning of electrification in Myanmar. It is designed to contain household, population, electrification status, demand, number of MEPE customers, statistic data, and maps in each state/division. These data are not completed yet and need to be supplemented and updated through the Database management.

Part 2 is technical data on the potential of renewable energy in Myanmar. It includes meteorological data such as temperature, rainfalls, sunshine hours, wind speed, as well as a list of rice-mills and agricultural residues so that users can see the order of potential available for electrification by type of renewable energy.

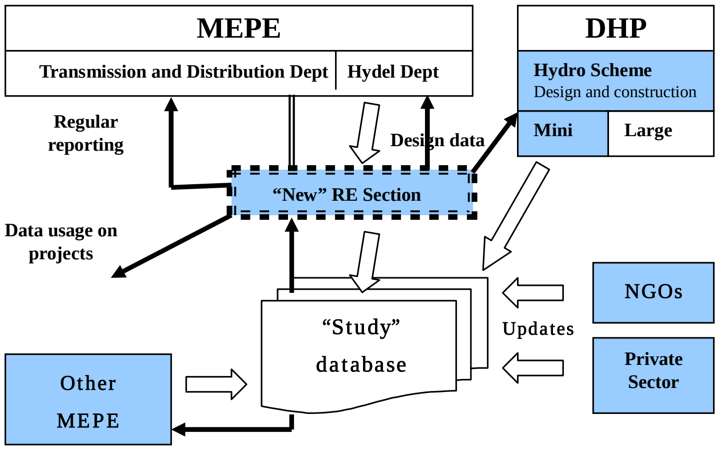
Part 3 is the database about RE projects. It contains such data that may be referred to in planning and implementation of RE projects. It contains information of *Government RE Schemes*, *Village RE Schemes*, *Social RE Schemes*, information for operation and maintenance, and laws and regulations concerning rural electrification in Myanmar.

Part 4 consists of technical information. It includes not only the outputs of the Study such as Guidelines, Manuals, and Development Plans, but also the other technical information that may be useful in RE schemes. These were collected from various sources such as internet resources, maker catalogues, journals, thesis, and project reports of various organizations. It also contains computer programs for the hydraulic and structural designing of civil structures appended to Design Manual-Small Hydros in Vol. 4.

15.3 Role of the Database and Key Users

The Database may be used for:

- Project formulation and planning,
- Information management, and
- Resource for preparation of reports concerning electrification using renewable energy



Source: JICA Study Team

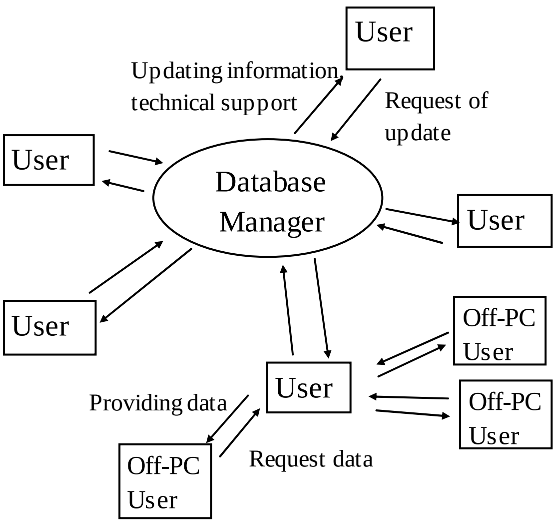
Figure 27 Diagram of Process Showing Key Users

The new RE Section will be the Manager of the Database. The other MEPE departments may need/provide the information concerning rural electrification. New RE Section distributes/updates the information. Cooperation of all the departments is important for the sustainable management of the Database such as collection and distribution of information. Acknowledge of the Database by all the departments at an early stage would be important. The other organization such as DHP, other government departments, and NGO are as well.

There would be three types of users, that is, Off-PC Users, Users, and Database Manager. Off-PC Users do not have an access to PC. It would be difficult for officers who are engaged in electrification in rural area to have computer access, but they may be the very people who need the information from the Database. In addition, they are the valuable information sources for the Database.

Users can operate the Database for the following:

- Finding and sorting out the information;
- File copying and printing out; and
- Updating by the Database Manager when appropriate.



Source: JICA Study Team

Figure 28 Database Users

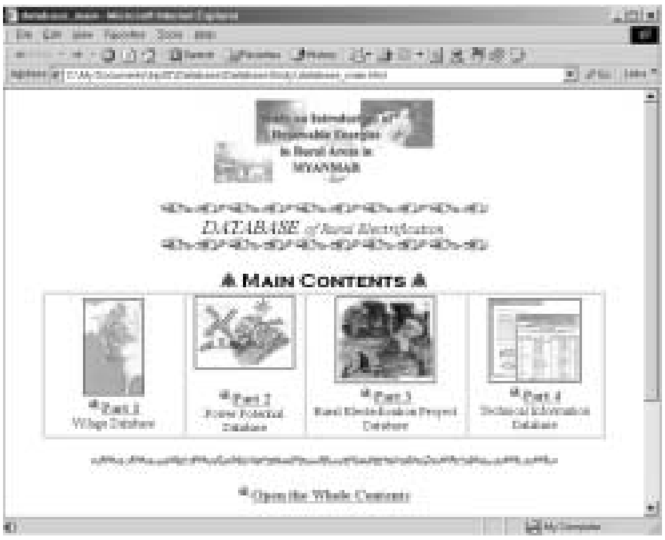
The Database Manager is the key person who is responsible for system management, updating, and distribution of the Database. The roles of the Database Manager are:

- Identification of the files that need to be updated;
- Collection and updating of the information/data files;
- Maintenance of the Database;
- Providing updated information to Users;
- Distribution of the Database according to requests from Users; and
- Providing technical support to Users.

15.4 Characteristics of the Database

The characteristics of the Database are:

- "Database viewer": It is made of HTML system operated in a browser such as Internet Explorer which is usually installed in standard Windows PC. It guides users to target files by clicks in visually arranged pages.
- Full-text search system: It enables to look up target words from among all the files in the Database.
- File list: It lists up all the files with outlines. Target files may be referred to by an overview of the file list.
- Updating is possible.



Source: JICA Study Team

Figure 29 Main Page of the Database Viewer

APPENDICES

Appendix-1 List of Village Hydros Installed by NGO

No.	Village	Township	Capacity	Unit	Type of Turbin	Year of Commis-sioning	Capital Cost (current) K. 1,000	US$	kW Cost US$/kW	Remark
1	MONG NAUNG	KYAAY SI	20	kW	Crossflow	1984	500	10,000	500	
2	PAN OUNT	HSI SENG	10	kW	Crossflow	1984	250	5,000	500	
3	MONG PON	LOI LEM	20	kW	Crossflow	1985	500	10,000	500	
4	MONG PON	LOI LEM	20	kW	Kaplan	1989	1,620	18,000	900	Nyaung Kyao
5	PIN DAWK	KENG TONG	20	kW	Crossflow	1986	500	1,000	50	
6	TI TAIN	TAUNGGYI	10	kW	Crossflow	1986	250	5,000	500	
7	PAN SAUK	HO PONE	7.5	kW	Crossflow	1987	270	4,500	600	
8	NAM KOKE	HO PONE	10	kW	Kaplan	1990	495	5,500	550	Monastery
9	DADAH GYI	PIN DAYA	14	HP	Kaplan	1990	504	5,600	560	U Soe New (oil mill)
10	DADAH GYI	PIN DAYA	15	HP	Kaplan	1990	540	6,000	560	U Aung Win (rice mill)
11	DADAH GYI	PIN DAYA	16	HP	Kaplan	1991	576	6,400	560	U Than Pe (sugar mill)
12	DADAH GYI	PIN DAYA	16	HP	Kaplan	1991	576	6,400	560	U Kyaw Kyaw (oil mill)
13	OH KONE	KUT KAI	12	HP	Kaplan	1992	528	4,800	560	Rice mill (home lighting)
14	MISSION SCHOOL	HSEN WI	12.5	kW	Kaplan	1992	688	6,250	500	
15	PONE TOON	HSEN WI	20	kW	Crossflow	1993	1,200	10,000	500	Owner Aik Yee
16	38TH MILE	HSEN WI	7.5	kW	Crossflow	1993	450	3,750	500	Owner B.K. Duo
17	HSEN WI	HSEN WI	50	kW	Francis	1994	3,000	25,000	500	
18	203 COMMAND	HSEN WI	10	kW	Kaplan	1995	600	5,000	500	
19	HOT SPRING	HSEN WI	10	kW	Kaplan	1995	600	5,000	500	Owner Mar Gum
20	MONG KNOWN	MONG KUCK	15	kW	Kaplan	1995	900	7,500	500	Monastery
21	WIN BO	KENG TONG	20	kW	Pelton	1996	1,200	10,000	500	
22	SAUNG HPOO	TAUNGGYI	75	kW	Francis	1996	4,500	37,500	500	
23	NAM BAY	TAUNGGYI	5	kW	Crossflow	2000	2,640	8,000	1,600	
24	P.N.O FARM	HSI SENG	15	kW	Crossflow	2000	2,475	7,500	500	
25	NAUNG BO	HSI SENG	5	kW	Crossflow	2001	1,050	3,000	600	
26	MONG SI	KUT KAI	10	kW	Kaplan	1999	1,584	4,800	480	
27	DAH MOE NYE	KUT KAI	10	kW	Kaplan	1999	1,584	4,800	480	
28	PAUNG SENG	KOO KANG	10	kW	Kaplan	2000	1,680	4,800	480	
29	LOI SAO	HSI SENG	5	kW	Crossflow	2000	1,050	3,000	600	
30	4TH MILE	HO PONE	16	HP	Crossflow	1989	768	6,400	560	Owner Htun Han
31	NAM PA MU	PIN LAUNG	5	kW	Crossflow	1999	990	3,000	600	Owner Myint Oo
32	SHWE PA SONE	BAHTOO	20	kW	Kaplan	1997	1,200	10,000	500	
33	Pin Bu	KYAW BA	15	kW	Crossflow	2001	2,450	7,000	470	
34	Thale U	NYAUNG SHWE	15	kW	Crossflow	2002	6,500	7,936	529	
35	Upper Nammye	TAUNGGYI	5	kW	Kaplan	2002	2,050	2,500	500	
36	Lower Nammye	TAUNGGYI	3	kW	Kaplan	2002				
37	Hon Po	TAUNGGYI	10	kW	Crossflow	2001	4,180	5,000	500	
38	Mai Te	HSI SENG	25	kW	Crossflow	2003	12,000	12,000	480	
39	Bone Shwe Pin	TAUNGGYI	30	kW	Crossflow	2003	12,500	12,500	417	
40	Nam Blin	PIN LAUNG	15	kW	Crossflow	2003	8,000	8,000	533	
41	Kyauk Ku	LAWK SAUK	5	kW	Propeller	2003	800	800	160	Power line is excluded
(Planning)										
42	Kyauktalone	HO PONE	125	kW	Francis	203				
43	Baw Lakae	KAYAH State	5	kW	Crossflow	2003	500	500	100	Distribution line is excluded

Source: U Khun Kyaw, Rural Development and Hydroelectric Implementation Group, Taunggyi, Shan State

Appendix-2 Features of Those Renewable Energy Not Dealt with in the Guidelines

No.	Source of Energy	Features
1.	**Geothermal Power**	● The potential sites are limited although there are volcanoes and hot springs in Myanmar. ● A large scale and costly drilling investigations will be required for potential study. Not suitable for *Village RE Schemes*.
2.	**Biogas Power**	● High temperature fermentation - central processing type of biogas power generation technology is expensive. Not suitable for RE. ● About 1,000 units of biogas engines are generating electricity in Germany. ● Medium temperature fermentation - independent processing type biogas technology is used for gas lighting and cooking widely in China and India and is considered prospective also in Myanmar. However, it is beyond the scope of the present Study for RE.
3.	**RDF (Refuse Derived Fuel) Power**	● As part of the urban environmental measures, this uses urban solid waste as fuel. Not suitable for RE.
4.	**Wave Power**	● Potential sites are limited to the western and peninsular coasts (average potential in Japan is reportedly 6 kW per m of sea coast). ● In order to save high capital costs, installation onto breakwater etc. would be required. Not suitable for RE.
5.	**Solar Heat Power**	● Although there are solar tower type, solar pond type, etc., these are of large scale requiring advanced technology. Not suitable for RE. ● Use of solar water heater is practical and recommended.

Source: JICA Study Team

Appendix-3 Unit Husk Consumption of Rice Husk Gas Engine

Younetalin village, Hinthada district, Ayeyarwady division installed a RH-14 (140 HP) rice husk gas engine and 135 kVA generator of MIC in April 2001. It has been supplying power to 420 households for 5 hours a day from 18:00 to 23:00.

The unit husk consumption was preliminarily estimated in the two ways as described below:

(1) 5 baskets of husk = 1 gallon of diesel

According to MIC, the typical husk consumption may be said that 5 baskets of husk = 1 gallon of diesel.

1.	Electricity that 1 gallon of diesel oil can generate	10 kWh (standard of MEPE old diesel generators of 100 kW+, corresponds to efficiency at 20.5% as (860 kcal/kWh x 10 kWh) / (4.546 l x 9,250 kcal/l). New diesel generator of 100 kW+ has efficiency of 32%.)
2.	Unit consumption of husk	5 baskets @ 11 pounds @ 0.454 kg = 25 kg
3.	kWh consumption of husk	25 kg/10 kWh = 2.5 kg/kWh

(2) 15 baskets of husk per hour at Younetalin village

1.	Daily husk consumption for 5 hour operation	60 baskets = 12 baskets/hour on an average
2.	Peak hourly husk consumption (MIC source)	15 basket @ 11 pounds @ 0.454 kg = 75 kg/hr
3.	Average power demand	(20 W lamps x 2 nos.) + 15 W electric appliance on average = 55 W
4.	Streetlights	20W x 40nos. = 0.8 kW
5.	Total power demand in the village	55W x 420 h.h. + 0.8 kW = 23.1 kW
6.	Power to be generated	23.1 kW x 1.05 (5% loss) = 24.3 kW
7.	kWh husk consumption	75 kg/hr / 24.3 kW = 3.1 kg/kWh

Source: JICA Study Team

The first estimate of the kWh husk consumption is 2.5 kg/kWh and the second is 3.1 kg/kWh. These figures in China are reported to be 2.0-2.2 kg/kWh. The first estimate of 2.5 kg/kWh is tentatively adopted in the Guidelines for basic planning of the RE schemes by rice husk gas engine. If the actual consumption is 3.0 kg/kWh, the rice husk will be needed by 20% more.

Appendix-4 Necessary Rice Husk for Village Electrification

Necessary Rice Husk for Power Supply

Assuming one household uses three numbers of 20 W fluorescent lights and electric appliances equivalent to 15 W average consumption, household consumption becomes 75 W. For the convenience of the basic planning, it may be assumed that unit power consumption is 80 W per household including 5% loss of distribution.

With the assumed unit husk consumption rate at 2.5 kg/kWh of the rice husk gas engine (see Appendix-3), the required rice husk for daily power supply for 5 hours would be as shown in Table A4.1.

Table A4.1 Required Husk for Power Supply by Gas Engine

Supply Hour at 5 hour/day

No.	Village Size	Rice Husk Consumption		
		Daily		Monthly
	h.h.	baskets	kg	kg
1	100	20	100	3,000
2	200	40	200	6,000
3	300	60	300	9,000
4	400	80	400	12,000
5	500	100	500	15,000

Source: JICA Study Team

Rice Husk Discharged from Village Rice-Mills

For example, assume a village size at 300 households (actual number of those who wish to receive power supply). Then, the daily rice husk consumption will be 300 kg (notice the same figure as the village size in the case of 5 hour power supply), and the monthly 9 tonnes.

In Myanmar the farmers keep paddy, after selling fixed amount to the Government, in his storage and sell it to the market depending on the market price. These paddy sold to the Government and market will be milled at medium to large scale rice-mills located near large cities or local towns and husks will be discharged there (not in the paddy cultivating region but near the consumption area).

On the other hand, the rice for self-consumption of the farmers will be milled from time to time at small scale village rice-mills mostly having a capacity of 2.5 tonnes/day and sometimes 10-15 tonnes/day. The rice husk produced from this milling will remain in the villages.

The amount of this village husk is estimated below:

Table A4.2 Power Potential of Husks only from Village Rice-Mills

● Average family size	6 persons per family
● Population in the village assumed	6 x 300 h.h. = 1,800
● Per capita rice consumption	Average in Myanmar at 130 kg/yr = 0.36 kg/day
● Total daily rice consumption in the village	0.36 kg/day x 1,800 = 650 kg/day
● The paddy to produce this rice	650 kg/day ÷ 0.61 = 1,060 kg/day
● The husk produced from this paddy	1,060 kg/day x 0.2 = 210 kg/day
● Possible power supply hours per day with this husk	210 kg/day ÷ (300 h.h. x 0.080 kW x 1 hr x 2.5 kg/kWh) = 3.5 hours

Source: JICA Study Team

As shown above, the husks produced from the village rice-mills through milling only for self consumption of the villagers have potential, if all the husks are used for power generation, to generate electricity for supply of 75 W (plus 5% loss) to each household for 3.5 hours a day. In other words, the husks only from the village rice-mills for self consumption are not sufficient for supplying power for 5 hours a day. Sources of rice husks should be sought also from outside the village.

Number of Village Rice-mills

As shown in Table A4.3, the village with 300 households would need 2-3 rice-mills of 2.5 tonnes/day capacity scale only for milling of the paddy for the villagers self consumption.

Table A4.3 Number of Village Rice-Mills Required for Self Consumption

● Operation months of 2.5 tonnes/day scale rice-mills	10 months a year except for September and October
● Operation days of the rice-mills	30 days x 10 months x 50% = 150 days
● Average rice production of one mill	2,500 kg/day x 12 hr/24 hr x 150 days/365 days = 514 kg/day
● Nos. of required 2.5 tonnes/day scale rice-mills in the village	650 kg/day ÷514 kg/day/rice-mill = 1.3 nos. → 2 rice-mills required.

Source: JICA Study Team

Existing Uses of Rice Husk

There are various kinds of uses of the rice husks as listed below:

- Cooking: 12 baskets of husks per family per month, equivalent to 12 x 11 pounds x 0.454 kg/pound = 60 kg/month = 2.5 kg/kWh x 24 kWh = 80 W x

10 hr x 30 days. The husk consumed for cooking is almost equivalent to that consumed for power generation of 80 W for 10 hours a day.

- Rice-mills, oil-mills, vermicelli drying factory, ice plant: rice husk gas engine is used as source of power and electricity for the plant. Some supply power also to the neighbouring households.
- Poultry: used for bedding materials and old ones are used as fertilizer.
- Brick, spirits distillery, pottery (water tanks): used as fuel for heating.
- Others (textile dying, some industry for heating, etc.)

In the case of rice-mills using husk gas engine as source of power, it consumes about one half of the husks produced. Accordingly, the greatest issue of the RE scheme with rice husk gas engine is to find and secure the source of husk supply nearby the village.

As biomass gas engine, it is theoretically possible to use, in addition to rice husk, wood chip, sawdust, comb of maize, aged rubber trees, etc. However, except for rice husk there is only one example of application of wood chip being used in a gold mine in Kachin State.

Appendix-5 Characteristics of Rural Area in Myanmar

(1) Rural Population

The population in Myanmar was 46,400,000 in 1997 and 75% lived in rural area[1].

(2) Agriculture as Major Industry

The agriculture sector shared 34% of the GDP at constant value, followed by the trade sector at 20%, and the processing and manufacturing sector at 9%[1].

The processing and manufacturing sector showed a low growth rate at 0.2%/year in the last 10 years. The insufficient power supply has been one of the causes of this very low growth rate[2].

(3) Population movement

Inflow of people into Yangon was recorded at 410,000, and 50,000 into Mandalay (labor force survey 1990). However, 500,000 people moved from urban to rural areas on the other hand. The ratio of urban and rural population has been almost unchanged. Such industrialization accompanied by the population movement from rural to urban areas as had been observed in the Asian countries in the past 20 years may have not taken place in Myanmar[3].

(4) Effect of Market Economy

In Myanmar the land belongs to the Government. The Government provides people with cultivating or utilizing rights of the farming land with registration. The people reportedly cannot sell such right or put it in pawn (*There is opposite information that people can sell and buy the right on the use of land*). However, the rental of such rights to other farmers was observed for short duration like within the dry season. For example, when the registered farmer has difficulty to implement the farming plan to follow the notices of the Government, he may lend his land temporarily to those who have necessary machines and fertilizer. These effects had been observed in the rural area after introduction of the change in the economic policy from the planned economy to the market economy in 1988[4].

(5) Township Chairman as Core of Rural Administration

The township SPDC are controlled and managed by the district and or divisional PDC. The township SPDC manages the township including quarters and village tracts. The chairman of township PDC is the center of the rural administration. The chairman is on volunteer basis[5].

(6) Donation to Monastery

Villagers in Myanmar have deep religious minds. Based on the understanding that donation is the most virtuous thing in the human's life, people have habit to donate all the reserve to monastery or monk at the end of each year. They keep the reserve when they need contribution to a village project like repairing school building, reconstruction of houses got fired, etc. There may be social and cultural background in Myanmar that supports promotion of RE on a self-help basis with villagers' leadership and contribution both in financing and labor[6].

(7) Average Education at Primary School

The Government implements the education system in three courses; Basic, Higher, and the Vocational Education. The Basic course starts from entering kindergarten at the age of 5 years, followed by 5 years of Primary School, 4 years for Middle, and 2 years for High School, resulting in a total of 11 years education. This is often referred to as 5-4-2 system. Those children who cannot attend Primary School may get education from private Monastic School system which is provided free of charge by monks at monasteries. Myanmar has preserved this education system since long years ago. There is a record showing 31 such schools were operated in 1867. The Ministry of Social Welfare, Relief and Resettlement provides night schools.

The 11 year education is referred to by continuous "Grade" from the First of Primary School to Tenth (first grade of High School). The Government provides the national examination called BEHS (Basic Education High School) to the students before graduation from High School. The students who passed the BEHS examination are graded "A" and are entitled to receive higher education at Universities or Institutes, and "B" to receive higher education for Teacher Training, Government Technical Institute, etc.

According to the Household Income and Expenditure Survey (1997), 70% of villagers completed Primary School, 16% not educated at all, 9% completed Middle School, and 3% completed High School. The ratio of higher education completed was at 1%, and vocational education at 0.2%[7].

(8) Medical and Healthcare

The Government provides medical and healthcare services in three stages. The primary stage consists of state hospital (SH), rural health center (RHC), sub center (SC) under RHC, and maternal and child health center. The second stage consists of district hospital (DH) and township hospital (TH). The tertiary stage consists of general hospital and specialized hospital. The district hospital and township Hospital are the centers of rural medical and healthcare services. There are 1,402 RHCs nationwide, equivalent to 17 times the primary and secondary service facilities in urban areas. However, the number of RHC may be small compared with the number of Primary School estimated at around 26,000[8].

(9) Income and Expenditure Levels

Monthly Income and Expenditure Survey was executed on 25,470 households nationwide including 45 townships both urban and rural in November 1997. The average monthly household income level was K13,006 for urban and K8,906 for rural. The average monthly household expenditure level was K15,266 for urban and K13,091 for rural. Countermeasures taken to fill the gap of the income and expenditure were not clear. In terms of the monthly rural household expenditure, Tanintharyi division was ranked at top at K19,041, followed by Shan State at K15,815, Kachin State at K15,494, and Kayin State at K14,947. All the top four states/divisions have international borders.

One of the characteristics of the expenditure is high Engel's coefficient; 68% in urban and 72% in rural[9].

(10) Expenditure for Lighting and Heat

The average monthly household fuel and lighting expenditure was K638 or 4.9% of the total expenditure. That for urban was K736 or 4.8%. The fuel type for cooking in rural households was firewood at 93%, charcoal at 4%, and electricity at

1%. Lighting source of rural household was 18% by electricity, 32% by battery, and 50% by others[9].

(11) Consumption Expenditure Level in 1999

CSO (Central Statistical Organization) of the Ministry of National Planning and Economic Development surveyed the monthly expenditure in 1999 on 3,240 urban and rural households in the six border townships. Though the surveyed townships were different from those surveyed in 1997, the expenditure was compared with the rural average of those states/division which the six townships belong to. The Engel's coefficient was at a similar level of 72%. The fuel and lighting expenditure was 1.6 point higher than the previous 5.0%. The expenditure figure was K27,107, being much higher than K15,015 in 1997[1].

(12) Income and Expenditure level in 2001

A village social survey was executed under the Study in order to get the latest data/information regarding the living conditions, villagers' needs for electricity, and their will for electrification. The survey was executed in May-June 2001. It was executed in Southern Shan, Northern Shan, and Kachin State.

The number of households surveyed is 1,348 in total comprising non-electrified (956) and electrified (392) households. Table A5.1 shows income and expenditure.

Table A5.1 Income, Expenditure, Saving, and Donation

(Units: Kyat/year/household)

Items	Non-electrified	Electrified	Total
1. Income	266,329	380,447	289,440
2. Expenditure	226,756	310,269	243,670
3. Saving	39,572	70,178	45,771
4.Donation	10,213	15,346	11,253
5. Per Capita Expenditure	39,782	43,700	40,612

Source: JICA Study Team

The income level in electrified villages was higher than that in non-electrified villages for all the three areas surveyed. It was K380,000 in electrified and K270,000 in non-electrified villages on an average, resulting in an overall average of K290,000 a year. The average per capita expenditure was K41,000 per year (K44,000 in electrified and K40,000 in non-electrified).

Appendix-6 (1/2) Estimated Unit Power Demand

Object	Accessibility ratio, %	Step		Watt	Simul-taneous use, %	Watt		Watt	Simul-taneous use, %	Watt
1. Household		1-1	a. 3 Lights	90	100		a. 3 Lights	90	15	
Shan South	87		b. Radio	10	30		b. Radio	10	15	
Shan North	84		c. TV (60w)	30	85		c. TV (60w)	30	15	
Kachin	93		Ownership ratio				Ownership ratio			
Total (Un-Ele	87		50%				50%			
ctrified)			Total	130	90%	118	Total	130	15%	20
Total (Electri-	92	1-2	1-1	130	90		1-1	130	15	
fied)			d. Rice Cooker	90	50		d. Rice Cooker	90	30	
Total	88		Ownership ratio				Ownership ratio			
			15%				15%			
			Total	220	70%	163	Total	220	20%	44
2. Public										
2.1 Street Light	100		1. 40w Tube 10/Place	50	100	2,000				0
2.2 Temple	100		1. Light 20wTubex30	600	67		1. Light 20wTubex30	600	0	
			2. TV 1x60w	60	50		2. TV 1x60w	60	0	
			3. Fan 4 x 60w	240	20		3. Fan 4 x 60w	240	50	
			4. Refrigerator(100w)	100	50		4. Refrigerator(100w)	100	100	
			5. A/C:1x1KW	1,000	0		5. A/C:1x1KW	1,000	50	
			Total	2,000	30%	528	Total	2,000	40%	720
2.3 Hospital	100		1. Outer light				1.Outer light			
			20w Tube x 1	20	100		20w Tube x 1	20	0	
			2. Inner light				2. Inner light			
			40w Tube x 5rooms	200	50		Night demand x 50%	200	25	
			3. Refrigerator				3. Refrigerator			
			130w x 1	130	100		130w x 1	130	100	
			Total	350	70%	250	Total	350	50%	180
2.4 Clinic	100		1. Outer light				1.Outer light	20	0	
			20w Tube x 1	20	100					
			2. Inner light				2. Inner light			
			40w Tube x 4rooms	160	50		Night demand x 50%	160	25	
			3. Refrigerator				3. Refrigerator			
			130w x 1	130	100		130w x 1	130	100	
			Total	310	70%	230	Total	310	50%	170
2.5 High School	100		1. Outer light	20			1.Outer light	20	0	
			20w Tube x 1							
			2. Inner light	5,760			2. Inner light	5,760	20	
			Class room (36)				For cloudy, rainy day			
			40w Tube x 4 x 36				use: 5,760x20% use			
			3. Head Master room				(50days/250days/year)			
			40w Tube x 1	40			3. Head Master room	40	20	
			4.Copy machine				4. Copy machine			
			300w x 10%	300			300w x 10%	300	10	
			5. Computer room				5. Computer room	80	100	
			40w x 2	80			40w x 2			
			Total	6,200	0%	0	Total	6,200	20%	1,270
2.6 Middle School	100		1. Outer light	20			1.Outer light	20	0	
			20w Tube x 1							
			2. Inner light	1,280			2. Inner light	1,280	20	
			Class room (8)				For cloudy, rainy day			
			40w Tube x 4 x 8				1.280x20%			
			3 Head Master room				(50days/250days/year)			
			40w Tube x 1	40			3. Head Master room	40	20	
			4 Copy machine	300			4. Copy machine	300	10	
			300w x 10%				300w x 10%			
			Total	1,640	0%	0	Total	1,640	20%	290

Source: JICA Study Team

Appendix-6 (2/2) Estimated Unit Power Demand

Object	Affordability ratio, %	Step	Watt	Simul-taneous use, %	Watt		Watt	Simul-taneous use, %	Watt
2.7 Primary School	100	1. Outer light	20			1.Outer light	20	0	
		20w Tube x 1				2. Inner light			
		2. Inner light	320			For cloudy, rainy day	320	20	
		Class room (8)				use:			
		40w Tube x 8				(50days/250days/year)			
		3 Head master room	40			3. Head Master room	40	0	
		40w Tube x 1							
		Total	380	0	0	Total	380	17%	65
3. Business									
3.1 Restaurant		1. Inner light	160	100		1. Inner light	160	0	
		40w Tube x 4							
		2. 21" CTV (95w)	95	100		2. 21" CTV (95w)	95	100	
		3. Refrigerator				3. Refrigerator			
		130w x 1	130	100		130w x 1	130	100	
		4. Rice Cooker				4. Rice Cooker			
		600w x 2	1,200	30		600w x 2	1,200	30	
		5. Hot plate				5. Hot plate			
		800w x 2	1,600	20		800w x 2	1,600	20	
		Total	3,185	30	1,070	Total	3,185	30	905
3.2 Guest House	100	1 Tube	4,400	50		1 Tube	4,400	20	
		20w x 22 room				20w x 22 room			
		2. 20w x 2 Toilet	40	20		2. 20w x 2 Toilet	40	20	
		3. Refrigerator	130	100		3. Refrigerator	130	100	
		130 w x1				130 w x1			
		4 Fan 60w x 4	240	50		4 Fan 60w x 4	240	50	
		5 21"TV	95	100		5 21"TV	95	100	
		95w x 1				95w x 1			
		Total	4,905	50%	2,550	Total	4,905	30%	1,230
3.3 Hotel	100	All facilities for 22 rooms/Hotel	7,000	80&	5,600	All facilities for 22 rooms/Hotel	7,000	70%	4,900
4. Cottage or Household Industry									
4.1 Rice Mill			5,000	0%	0	1. Motor	5,000	80%	4,000
4.2 Oil Mill			7,000	0%	0	1. Motor	7,000	80%	5,600
4.3 Powder Mill			5,000	0%	0	1. Motor	5,000	80%	4,000
4.4 Sugarcane Processing			5,000	0%	0	1. Motor	5,000	80%	4,000
4.5 Saw Mill			5,000	0%	0	1. Motor	5,000	80%	4,000
4.6 Paper Mill			5,000	0%	0	1. Motor	5,000	80%	4,000
4.7 Tofu Manufacturing			4,000	0%	0	1. Motor	4,000	80%	3,200
4.8 Noodle Mill			7,000	0%	0	1. Motor	7,000	80%	5,600
4.9 Furniture Manufacturing			5,000	0%	0	1. Motor	5,000	80%	4,000
4.10 Iron Work (including car, Trawlergyi, boa etc.repair shop)			4,000	0%	0	1. Motor	4,000	80%	3,200
4.11 Battery Charge Station (BCS)			1,500	0%	0	1. Motor	1,500	80%	1,200
4.12 Weaving			5,000	0%	0	1. Motor	5,000	80%	4,000
4.13 Water Pump			200	0%	0	1. Motor	200	80%	160

Note: It is assumed 15% of householdswill have 600 W rice cooker several years after electrification.
In Nam Lan township, two sawmills have in total four sawing machines, each having ca capacity of 20 kW.
Source: JICA Study Team

Appendix-7 (1/4) Selection Criteria for RE by Small and Mini Hydros (>50kW)

No.	Parameters	Criteria for Selction (Qualification)
1	Possibility of extension of distribution lines from Grid	L > 30 km or Grid has no extra power for RE --> then by hydro
2	Possibility of power supply by rehabilitation of existing small hydros nearby	Not exist, or not possible to rehabilitate --> then by new hydro
3	Length of new access road	L < 10 km
4	Length of road from site to target villages	L < 0 km
5	Number of households in the target villages	n > approximately 500
6	Installed capacity P_i	50 kW < P_i < 10,000 kW
7	Intake weir height	H < 15 m
8	Storage dam height	H < 50 m
9	Pond/reservoir surface area	A < 5 km^2
10	Headrace tunnel	L < 2,000 m
11	Headrace channel	L < 5,000 m
12	Penstock	L < 1,000 m
13	Design head of turbines	H_d < 500 m
14	Design discharge of one turbine	Q_d < 2.0 m^3/s
15	Type of powerhouse	surface

Source: JICA Study Team

Appendix-7 (2/4) Selection Criteria for RE by Village and Pico Hydros (<50kW)

No.	Parameters	Criteria for Selction (Qualification)
1	Possibility of extension of distribution lines from Grid	L > 10 km or Grid has no extra power for RE
2	Possibility of power supply by rehabilitation of existing small hydros nearby	Not exist, or not possible to rehabilitate
3	Length of new access road	L < 1 km
4	Length of road from site to target villages	L < 1 km, if it exceeds 1 km, costs of transmission lines will significantly increase.
5	Number of households in the target villages	n < 300-500
6	Installed capacity P_i	$P_i < 50$ kW
7	Design head of turbines	$H_d < 30$ m
8	Design discharge of one turbine	Preferably $Q_d < 0.5$ m^3/s in general, refer to Design Manual-Village Hydros in Vol. 4 for required discharge by head and village size.

Source: JICA Study Team.

Appendix-7 (3/4) Selection Criteria for RE by Solar-Wind BCS

No.	Parameters	Criteria for Selction (Qualification)
1	Possibility of extension of distribution lines from Grid	L > 1 km
2	Existence of ricemills or sawmills nearby	Not exists nearby except for small scale ones which cannot meet fuel requirement of Biomass Gas Engine
3	Existence of adequate hydro potential nearby	Not exists.
4	Accessibility to the target villages (road driving hours from Yangon, Mandalay, or other large urban centers nearby in the rainy season)	T > 3 hr or road not passable in the rainy season
5	Number of households in the target one village	n < approximately 100

Source: JICA Study Team.

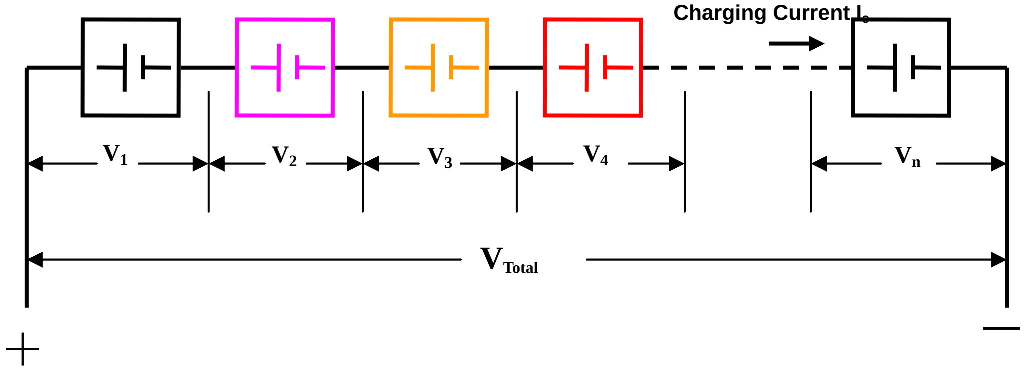
Appendix-7 (4/4) Selection Criteria for RE by Biomass Gas Engine

No.	Parameters	Criteria for Selction (Qualification)
1	Possibility of extension of distribution lines from Grid	L > 1 km or Grid has no extra power for RE
2	Existence of suitabe hydro potential nearby	Not exists.
3	Existence of ricemills or sawmills	Exists nearby and can meet the fuel requirement of Biomass Gas Engine
4	Number of households in the supply area	500 > n > 100, a village of smaller size would increase unit cost per household beyond affordable range.

Source: JICA Study Team.

Appendix-8 Common Issues of Battery Charging for Lighting and Recommended Parallel Charging

It is quite common that batteries are serially connected for charging at BCSs in Myanmar. However, this serial charging will deteriorate batteries. All of the batteries connected would have different conditions in charging impedance, state of remaining energy, and voltage capacity. Life expectancy of each battery is also different. A deteriorated battery has large impedance. When these batteries are charged under serial connection, some deteriorated batteries will be over-charged and the others will get insufficient power for charging. Repetition of the over-charging or under-charging will shorten the life of the batteries. Charging should be executed to the full charged revel.



Source: JICA Study Team

Figure A8.1 Constitution of Charging Voltage

V_{total} = $V_1+V_2+\cdots+V_n$

= $I_c \times R_1+ \cdots I_c \times R_n$

where, V_{total}: Tatal voltage

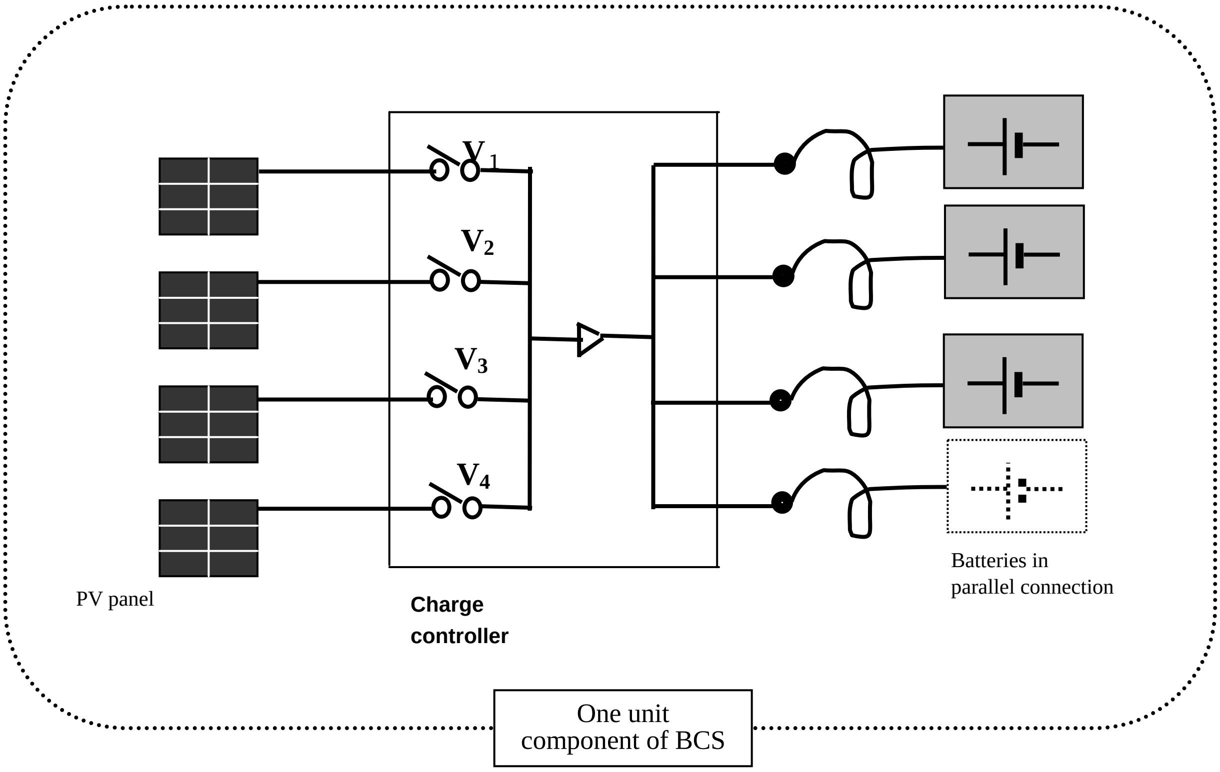
$V_1 \cdots V_n$: Battery voltage under charge

I_c : Charging current

$R_1 \cdots R_n$: Charging impedance of batteries

I_c is common among the batteries serially connected. The impedance of a deteriorated battery is higher than rated impedance of normal battery. Mixing an over-used battery of large impedance (ex. R_4) in the serial connection will increase its charging voltage V_4 (= I_c x R_4) exceeding the allowable voltage, which leads to cause electrolysis of the battery water. Energy intended for charging is consumed for the electrolysis, and the charging current I_c of the system is reduced. Then, a longer time is needed for the charging of the other normal batteries. On the other hand, it drops the charging voltage of the other batteries V_1, V_2,…, as V_{total} is constant, and the charging finishes before these are fully charged (since charging at BCS is usually ended by time elapsed). Half-charging causes the eduction of lead on the electrode, which shorten the battery life.

To avoid these problems, all of the batteries of the same rated voltage, 12 V for example, should be connected in parallel as shown in Figure A8.2, where all the batteries are to be charged under the same voltage up to the fully charged voltage level. Batteries of different voltage should be separately charged. Otherwise the life of batteries will be significantly shortened.



Source: JICA Study Team

Figure A8.2 Recommended Parallel Connection for Battery Charging

Appendix-9 Forms for Interview Survey for RE with Solar-Wind Power

(1/2) Form for Demand Survey of Each Consumer

Type/Name of Consumer: ______________________________

Date of survey: ____________________

Fill in features like family size for household, number of pupils for school, etc.

No.	Electric Appliances	Type DC	Power W A	Number B	Voltage V C	Daily Use hours D	E (Wh/day) AxBxD
1	Lamp	FL	20	1	12	5	100
2	Lamp	Bulb					
3	Lamp						
4	Radio	RadiCasse					
5	TV						
6							
7							
		Total Appliaces No:		1	Total Power Use: **(E)**=		100

2. Calculation of Battery Capacity

Power Demand, Pd=	(E)/0.706/0.87=		163	Wh/day
Battery Voltaga:	V=		12	Volt
Charging Interval:	Int=		4	days
Battery Capacity: Bc=	Pd x Int/V/0.7=		78	Ah
Choose Battery Capacity from here:			10, 20, 30, 5(	Ah
Your Battery Capacity:	50	Ah x	2	Cells

3. Now, Your power consumption is estimated as 3.0 kWh/month.

So, You will have to pay money of 15 Kyat every month,

since the unit charge will be estimated as 5 Kyat/kWh. (Note-3)

(light grey)	Data Input Column
(dark grey)	Automatic Calculation

Note: If nothing particular, select appliances based on 12V, which is highly recommended and economical. The selection of voltage lower than 12 V would be more expensive in total lifetime cost than that of 12 V.

(2/2) Form for Village Summary

Sheet No: /

Village Name ____________________________ **Township:**__________________________

Total No of Household ____________________ **State:** ___________________________

No.	Name	Power Demand Wh/day	Required Nos. of Batteries by Size Standard, 12V			Remarks
			50Ah	30Ah		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
Total for Housholds Use:						
	Monastery					
	Primary School					
	Village Office					
	Clinic					
	Community Center					
Total for Public Facilities Use:						
Grand Total						

Appendix-10 Planning Sheets for RE by SHS

Table A10.1 Past Example of SHS Installations in Foreign Countries

1	Name of Country	Sri Lanka	Indonesia	Nambia	Brazil	Bolivia		
2	Reported Year	Started from 1997	Started from 1997	Started from 1997	Started from 1995	Started from 1996	Started from 1998	Started form 2001
3	Fund	GEF,RB	WB	SUSAID, Covernment, etc	GTZ/CEMIC	Government of Spain	USAID	JICA
4	System Configuration							
	1) PV Panel	50W x 1 set	50W x 1 set	50W x 1 set, 100 W x 1 set	50W x 1 set	50 W x 1	53W x 1 set	50W x 1 set
	2) Battery	100Ah x 1set	70 Ah x 1 set	100 Ah x 1 set	100Ah x 1set	100 Ah x 1 set	100 Ah x 1 set	99.12Ah
	3) Controller	1 set	1 set	1set	1 set			1 set
	4) Lamp	10W x 7 sets				15W x 3 sets	7 W x 3 sets	15W x 3 sets
	5) Wall Sockets	8 sets						
	6) Internal Wiring	1 set for all above						
5	Way of Operation	Personal Ownership	Personal Ownershi	Personal Ownership	Rental to Users	Rental to Users	Personal Ownership	
6	Bank Loan System							
	1) Initial Installment	Rp 115.75 *1	US$ 75-100	20% of capital cost			USD 90	Bs.600*3
	2) Monthly Payments	Rp 13.89	up to US$ 10	Payment to be finished		US$ 2	None	Bs. 22
	3) Payment Months	36 Months	48 Months	within 5 years			None	
	4) Maintenance Cost	Included above						
	5) Monthly Rental Fee				US$ 5			
	6) Payment Condition			Yearly interest at 5%			No interest	
7	Others							
	1) Total Repayment by Loan System	Rp 615.75		US$ 892, USD 1,700		US$ 700	US$ 720	Bs.5300
	2) Cost of Lump-sum Payment	Rp 509.26						
8	Data Source	Direct Interview in October, 2001	JEPEA Report, March, 2001	JEPEA Report, March, 2001	JEPEA Report, March, 2001	JICA Report, September, 2001	JICA Report, September, 2001	JICA Report, September,2001

*1 Japan Photovolatic Energy Association
*2 US$1 = Rp 86.4 as of October 10, 2001
*3 US$1 = Bs.5.98 as of September, 2001

Table A10.2 Planning Sheet for SHS

		Calculation for	**Village of :**						
		Calculation Item							
	1.	**Name of System** **Numbers**	**Unit**		Power, W	Hour	No.	Wh/day	
Demand		Village "Sample" 50	Sets	Lamp	20	5	1	100	
				Lamp				0	
				Radio	5	5	1	25	
				Others	6	0		0	
				Total	*	*	2	125	
		Daily Total Power Demmand :	P_{DD}	125	Wh/day				
		Monthly Total Power Demand :	P_{MD}	4.7	kWh/Month			(Note-4)	
	2.	**Battery**							
Battery Capacity	a)	Type of Battery		Acid-lead (A/L) battery, recyclable batteries commonly used in Myanmar					
	b)	Ah-Capacity Ah	C_B	50	Ah				
	c)	Nominal Voltage	V_N	12	Volt				
	d)	Total Capacity of Battery Bank	C_{BB}	600	Wh X Nos of battery				
Battery Efficiency	e)	Charge-discharge efficiency of L/A Battery	K_3	83%					
	f)	Inferiority against L/A Battery	K_{INF}	85%					
	g)	Total Efficiency of Charge-discharge	K_{total}	70.6%					
	h)	Circuit Loss Factor	K_4	0.87					
	i)	Interval of Battery Charge:	D_A	4	days				
	j)	Depth of Discharge	B_{DOD}	70%					
Battery requirement	k)	Required Capacity of Battery	C_{CB} *1	97.0	Ah			(Note-3)	
	l)	Nos of Battery	N_B	2	Cells				
	3.	**Calculation of PV Array Capacity**							needed for PV only
Factors peculiar to PV	a)	Unit Capacity of PV Panel	C_P	50	W				
	b)	Conv. Efficiency of PV Panel	E_P	12.5%					
	c)	Area of PV Panel	A_P	0.4	m^2				
Factors dependedt on area condition	d)	Irradiation	R_M	4.35	$kWh/m^2/day$			(Note-1)	
	e)	Margin Factor for PV Capacity	M	1.25					
	f)	Temp Degradation Factor	K_1	0.84					
	g)	Panel Contamination Factor	K_2	1.00	0.9 , if necessary			(Note-2)	
	h)	Other Loss Factor	K_M	0.90					
	4.	**Array Capacity**							
	a)	Calculated No of PV Module:	N_P	2	Sheets				
	b)	Calculated PV Array capacity:	C_{PV} *2	100	W				
	5.	**Durability of Battery**							
	a)	Calculated Interval		4.12464	days				
	b)	Durability		OK					
	6.	**Total Capacity**							
	a)	No. of Household		50	household				
	b)	Total Batteries used in theVillage		100	Sets				
	c)	Total PV Capacity for Village		5	kW				
	d)	Total Wind Turbine Capacity			kW X			(Note-5)	

***1** $C_{CB} = P_{DD} \times D_A / V_N / (K_3 \times K_{INF}) / K_4 / B_{DOD}$

***2** $C_{PV} = C_P * N_P = C_P \times P_{DD} \times M / 1000 / R_M / (K_3 \times K_{INF}) / K_4 / K_1 / K_2 / K_M / E_P / A_P$

Note-1: Yearly Mean Irradiation Data of DOMH at Myitkyna (Max:5.60, Min:3.25kWh/m2/day)

Note-2: If necessary, to be replaced with "0.9" in stead of "1.0"

Note-3: Margin Factor(**M**) is not included here. If necessary, to be included.

Note-4: Margin Factor(**M**) is included here.

Note-5: For rough information, Wind Turbine Capacity to be estimated by referring Table A11.2 & Table A

Data of Typical PV Panel Specification								
Output	Wp		50	52	54	56	60	64
Efficiency	%		12.5	13.0%	13.5%	14.0%	12.3%	11.5%
Area	m2		0.40	0.40	0.40	0.40	0.490	0.5583
Manufacture		Mono-Silicon Type					Kyosera	MSK

Note for Input:	
	Data Input Column
	Coefficient, fixed
	Coefficient, variable
	Automatic Calculation

Appendix-11 Planning Sheets for RE by Solar BCS

Calculation Model: **50** housholds **20** W x **5** hr/da **1** set

	Calculation Item	Case Study		Notes and Calculation Form
1.	Village Facilities	Total Power Demar		
1)	Power Demand for Public Facilities			
a)	Primary School	215	wh/day	
b)	Village Office	210	wh/day	
c)	Clinic	180	wh/day	
d)	Community Center	0	wh/day	
	Power Demmand for P-facilities	605	wh/day	
	No of allotted batteries	11	Batteries	
2)	Households Use	No. of Households: 50	HH	
	Total Power Dmand	6250	wh/day	
	No of allotted batteries	100	Batteries	
3)	Grand Total of Power Demand	6855	wh/day	
	Total No of Batteries	111	Batteries	
2.	Battery			
a)	Type of Battery	Recyclable Batteries commonly used in Myanmar		
b)	Ah-Capacity and Nos Ah		Ah	(Note-3) (Note-4)
	Nos		Cells	
c)	Nominal Voltage	12	Volt	
d)	Capacity	67	kWh	=E23*E25
e)	Charge-discharge efficiency of L/A battery	83.0%		Degradation Factor
f)	Inferiority against L/A Battery	85.0%		Assumption Factor
g)	Total Efficiency of Charge-discharg	70.6%		=E27*E28
h)	Circuit Loss Factor	0.87		=ROUND(1-(1.5/12)*1.05,2)
f)	DOD	70%		
3.	Calculation of PV Array Capacity			
a)	Unit Capacity of PV Panel	54	W	PV Caracteristic
b)	Conv. Efficiency of PV Panel	13.5%		PV Caracteristic
c)	Area of PV Panel	0.4	M2	PV Caracteristic
b)	Interval of Battery Charge:	4	days	
c)	Irradiation	4.35	$kWh/m^2/d$	Note-3
d)	Margin Factor for PV Capacity	1.25		0capacity Margin
e)	Temp Degradation Factor	0.84		Degradation Factor
f)	Other Loss Factor	0.90		Degradation Factor

Power Demand for Public Facilities furnished with Lamps and Radio & Others

		Power W	Duration hour/day	No set	Total Wh/day	Load	Power W	Duration hour/day	No set	Total Wh/day
Primary School	Lamp	20	5	2	200	Radio	5	3	1	15
Village Office	Lamp	20	3	3	180	Radio	5	3	2	30
Clinic	Lamp	20	3	2	120	Radio	5	3	4	60
Community Center	Lamp				0	Radio				0
Total				7	500	Total			7	105

Power Demand for Households

	Power W	Duration hour/day	No set	Total Wh/day
Lamp	20	5	1	100
Lamp				0
Cassette	5	5	1	25
Total			2	125

Calculation of Battery Capa

Demand Objects	Battery Cap & No Ah Cap.	Ah	Nos	Total No	Battery Nos & Capacity Ah-Class		Nos	Wh Capacity	
H/H	97	50	2	100	30	Ah	0	0	
P School	166.9	50	4	4	40	Ah		0	
V Office	163	50	4	4	50	Ah	111	66600	
Clinic	139.7	50	3	3	75	Ah	0	0	
C Center	0				100	Ah	0	0	
Total				111	150	Ah			
					200	Ah			
					Total		111	67	kWh

Data Sheet: PV Panel Specification

Output	Wp	52	54	56	60	64
Efficiency	%	13.0%	13.5%	14.0%	12.3%	11.5%
Area	m2	0.40	0.40	0.40	0.490	0.5583
Manufacture		Mono-Silicon Type			Kyosera	MSK

	Item	(Total for BCS)	(BCS/Household)	(SHS/P School)	(SHS/V Office)	(SHS/Clinic)	(SHS/C Center)	(Total for BCS+SHS)	Notes
4.	Array Capacity								
a)	Calculated No of PV Module:	79 Sheets	72 Sheets	3 Sheets	3 Sheets	3 Sheets	0 Sheets	81 Sheets	Note-1
b)	Calculated PV Array capacity:	4.27 kW	3.89 kW	0.16 kW	0.16 kW	0.16 kW	0 kW	4.37 kW	=ROUND(E42*E33/1000,2)

	Item	(Household)	(P School)	(V Office)	(Clinic)	(C Center)	Notes
5.	Durability of Battery for H/H						
a)	Calculated Interval	4.12 days	4.80 days	4.91 days	4.30 days	days	Note-2
b)	Durability	OK	OK	OK	OK		=IF(E46/$E36>1,"OK","No Good")

Note for Input: Data Input Column; Coefficient, fixed; Coefficient, variable; Automatic Calculation

Note-1: =ROUNDUP(E19*E38/1000/E37/E29/E30/E39/E40/E34/E35,0)
Note-2: =(Battery Capacity in use)x12x(DOD/100)/(Daily Power Demand)
Note-3: =IF(K23<50,10*ROUNDDOWN((K23/10+1),0),10*ROUNDDOWN((K23/2/10+1),0))
Note-4: =1+ROUNDDOWN(K23/E23,0)

Table A11.1 Planning Sheet of Solar PV Array for BCS (Sample for 50 Households Village)

Table A11.2 (1/2) Cost Estimate for Solar BCS (Sample for 50 Households Village)

No.	Items	Specification	nos.	Unit	Unit Price			Price
					Kyat or Yen		US$	US$
(A)	**BCS**							
(1)	PV Array							**7,562**
1)	PV Module	54W	79	set	30,000	Yen	60	4,740
2)	Terminal Box		32	set	40,000	Yen	80	2,560
3)	Arrester		77	pce	400	Yen	0.8	62
4)	Array Structure	Wooden & Aluminum Structure	1	set	100,000	Ky	200	200
							0	0
(2)	Controll Units							**4,920**
1a)	Charging Controller	1P/4P-12V, 20A Normal Ver.	20	set	80,000	Yen	160	3,200
1b)	Charging Controller	1P/4P-Variable V, 20A	12	set	20,000	Yen	40	480
1c)	Charging Controller	4P/4P-Variable V, 20A: Eco-Charge	3	set	200,000	Yen	400	1,200
2)	Management Board		1	set	20,000	Yen	40	40
							0	0
(3)	Domestic Utensils							**7,149**
1a)	Mobile Battery	Recyclable 12V, 50Ah made-in-Mya	134	set	17,000	Ky	34	4,556
1b)	Mobile Battery	Recyclable 12V, 75Ah	0		21,000	Ky	42	0
2a)	Lighting Kit	FL-20W	69	set	6,500	Ky	13	897
2b)	Lighting Kit	FL-10W			4,000	Ky		
2c)	Lighting Kit	FL-8W		set	3,500	Ky	7	0
3)	Radio for Public Use	No inclusion for personal use	8	set	25,000	Ky	50	400
4)	Internal Wiring Set		72	set	9,000	Ky	18	1,296
5)	Others		1	set		Ky	0	0
						Ky	0	0
(4)	Construction Work							**3,404**
1)	Erection Materials							1,428
a)	Cable & Wire	817,500	1	set	355,900	Ky	711.8	712
b)	Miscellaneous cabling materials	262,500	1	set	114,300	Ky	228.6	229
c)	Supportstructure & basement	560,000	1	set	243,800	Ky	487.6	488
2)	Workers	100	76	M-D	2,000	Ky	4	304
3)	Foreman	Electrician 15	12	M-D	4,000	Ky	8	96
4)	Manager	Engineer 15	12	M-D	9,000	Ky	18	216
5)	Designer	Engineer 15	12	M-D	15,000	Ky	30	360
6)	Transportation	1	1	set		Ky	1000	1,000
							0	0
(5)	Miscellaneous							**0**
1)						Ky	0	0
						Ky	0	0
	Total Summation for Item A							23,035
B	Battery Recycling Shop							
(1)	Necessary utensils, tools, working tables., etc.							**1,024**
1)	solar still		2	Set	80,000	Ky	160	320
2)	lead mould		2	Set	10,000	Ky	20	40
3)	lead nelting tool with compressor & nozzel		2	Set	50,000	Ky	100	200
4)	plates mounting jig set		2	Set	14,000	Ky	28	56
5)	water tank		1	Set	18,000	Ky	36	36
6)	acid soultion container		1	Set	12,000	Ky	24	24
7)	workshop table		1	Set	70,000	Ky	140	140
8)	plier,cutter & miscellaneous tools		1	Set	20,000	Ky	40	40
9)	tools and equipment shelf		1	Set	50,000	Ky	100	100
10)	hydrometer		1	Set	4,000	Ky	8	8
11)	thermometer		1	Set	1,500	Ky	3	3
12)	state of charge meter		1	Set	3,500	Ky	7	7
13)	multimeter/tester		1	Set	25,000	Ky	50	50
						Ky	0	0

Table A11.2 (2/2) Cost Estimate for Solar BCS (Sample for 50 Households Village)

No.	Items	Specification	nos.	Unit	Unit Price			Price
					Kyat or Yen		US$	US$
(2)	Provision of all parts and materials for recycling							**230**
1)	lead raw materials (50 sets)	16,000	1	Lot	9,200	Ky	18.4	18
2)	electrolite	9,000	1	Lot	5,200	Ky	10.4	10
3)	seperater	2,000	1	Lot	1,200	Ky	2.4	2
4)	standard lead plate	54,000	1	Lot	31,100	Ky	62.2	62
5)	empty battery	35,000	1	Lot	20,200		40.4	40
6)	battery cap & cover	3,500	1	Lot	2,100		4.2	4
7)	spare cabinet	75,000	1	Lot	43,100		86.2	86
8)	miscellaneous	5,000	1	Lot	2,900		5.8	6
(3)	Others for repairing							**0**
1)	Operator	10%				Ky	0	0
2)						Ky	0	0
	Total Summation for Item B							1,254
C	Shop with Stock Room							
(1)	Necessary utensils, tools, working tables., etc.					Ky		**200**
	Please specify here.		1	Set			0	0
							0	0
(2)	Provision of all FL lamps, electric/electronic parts and materials					Ky		122
1)	PV Module	54W =ROUNDUP(Calc_BCS!E3	2	set	30,000	Yen	60	120
2)	Terminal Box	=ROUNDUP(Calc_BCS!E3	1	set	40,000	Yen	80	80
3)	Arrester	=ROUNDUP(Calc_BCS!E39*N10*(1+N8	2	P's	400	Yen	0.8	2
	Charging Controller	1P/4P-12V, 20A Normal Ver.	1	set	80,000	Yen	160	160
	Charging Controller	1P/4P-Variable V, 20A	1	set	20,000	Yen	40	40
	Charging Controller	4P/4P-Variable V, 20A: Eco-Charge	1	set	200,000	Yen	400	400
	Mobile Battery	Recyclable 12V, 50Ah made-in-Mya	7	set	17,000	Ky	34	238
	Mobile Battery	Recyclable 12V, 75Ah	0		21,000	Ky	42	0
	Lighting Kit	FL-20W	4	set	6,500	Ky	13	52
	Lighting Kit	FL-10W	0		4,000	Ky		
	Lighting Kit	FL-8W	0	set	3,500	Ky	7	0
	Radio for Public Use	No inclusion for personal use	1	set	25,000	Ky	50	50
	Internal Wiring Set		4	set	9,000	Ky	18	72
(3)	Others						0	0
	Total Summation for Item C							322
D	Building	2 Rooms: one for Charging Room, another for BRSp Room						
(1)	Charging Room	36 m2	1		1,250,000	Ky	2500	2,500
		Total Area: 6x6m2	36		47	U$/m2		1,692
	Unit Cost 47	=ROUNDUP(61.43/(64/9.3)^0.2,0)					0	0
(2)	BRSp Room	36 m2	1		1,250,000	Ky	2500	2,500
		Total Area: 6x6m2	36		47	U$/m2		1,692
	Unit Cost 47	=ROUNDUP(61.43/(64/9.3)^0.2,0)					0	0
(3)	Shop with Stock Roon	18 m2 6x3m2	1		625,000	Ky	1250	1,250
		Total Area: 6x6m2	18		54	U$/m2		972
	Unit Cost 54	=ROUNDUP(61.43/(d113/9.3)^0.2,0)					0	0
	Total Summation for Item D							4,356
E	Management Work							
(1)	Consulting		60	M-D	35,000	Ky	70	4,200
(2)	Travelling Cost		3	set		Ky	300	900
(3)	Documetation		1	set	1,000,000	Ky	2000	2,000
(4)	On-site training work		1	set	1,500,000	Ky	3000	3,000
	Total Summation for Item D							10,100
	Grand Total for implementation of B CS, Type-1							39,067

Appendix-12 Planning Sheets for RE by Wind Power BCS

Table A12.1 Mean Wind Speed and Required Number of Wind Turbine-Generator

1)	Type of Wind PG		**Whisper 3000 (IWANAKA, Japan)**										
2)	Monthly Mean W.V.		2.7m/s	3.1m/s	3.6m/s	4.0m/s	4.5m/s	4.9m/s	5.4m/s	5.8m/s	6.3m/s	6.7m/s	7.2m/s
3)	Monthly Power Output	kWh/M	56	102	162	233	316	408	507	611	715	818	916
4.	Calculation of Wind PGS												
a)	Calculated Power Demand		600 kWh/Month										
b)	Calc of W/T PG		10.7	5.9	3.7	2.6	1.9	1.5	1.2	1	0.8	0.7	0.7
c)	Nos of W/T PG	Set	**11**	**6**	**4**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**

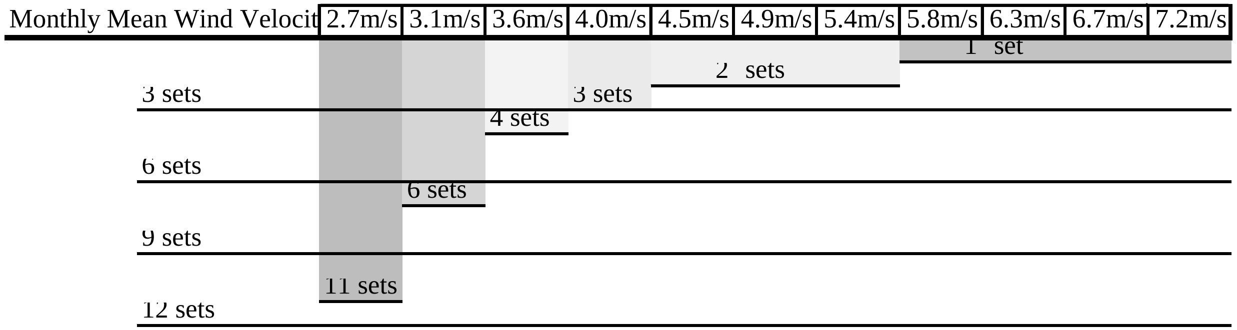


Table A12.2 Examples of Estimated Power Outputs from Small Wind Turbines

(Unit: kWh/Month)

No	Type of Wind Turbine	Monthly Mean Wind Velocity										
		2.7m/s	3.1m/s	3.6m/s	4.0m/s	4.5m/s	4.9m/s	5.4m/s	5.8m/s	6.3m/s	6.7m/s	7.2m/s
1.	Whisper 600	11	20	32	47	63	82	102	122	143	164	183
2.	Whisper H900	11	20	32	47	65	86	109	134	160	187	214
3.	Whisper 1000	19	34	54	78	105	136	156	204	238	273	305
4.	Whisper H1500	18	34	54	79	108	143	181	223	265	312	357
5.	Whisper 3000	56	102	162	233	316	408	507	611	715	818	916
6.	Whisper H4500	54	100	161	236	325	428	543	668	800	936	1070

Data Source: Iwanaka Denki Seisakusyo, Sagamihara city, Japan

Note: Use Table A10.2 for planning of battery.

Appendix-13 Suppliers and Contractors in Construction Industry in Myanmar Market

No.	Resources	Consultants/Maker/Supplier
1.	Topo-survey	Concordia International, Yangon, Tel. (1)544 824
2.	Geological investigations, assessment	U Sann Lwin, Consulting Engineering Geologist, Professor Emeritus, Yangon University
3.	Investigation, planning, and design of small hydro Construction Pico turbine/ generator	U Khun Kyaw, Rural Development & Hydroelectric Implementation Group, Taunggyi, Shan State Aung Pyi Tun Construction Ltd., Yangon, Tel. (1)663 608 National Engineering & Planning Services (NEPS), Yangon, Tel. (1) 705 197 Emerald Green Co-op Ltd., Tel. 662 417, 546 174 ECODEV, Yangon, Tel. (1) 222 048
4.	Planning of rice husk gas engine, solar and wind power	Myanmar Inventors Cooperative Ltd., Yangon, Tel. (1) 666 763
5.	Supply of materials (cement, reinforcing bars, concrete pipes, timbers, etc.)	Shaheen Co.,Ltd (Yangon), Tel. - (95 - 1) 590199 Madina (Mandalay), Tel. - (95 - 2) 25453, 35085 Ko Myo Win (Shwe Innwa), Tel. - (95 - 2) 28113, 31640
6.	Gates, screens, penstock pipes	Triangle Link Engineering Co., Ltd., Yangon, Tel. (1) 558 176 U Khun Kyaw, Rural Development & Hydroelectric Implementation Group, Taunggyi, Shan State Sein Pann Industrial Production Co-op Ltd., Mandalay, Tel. (2) 88423 Taing Kyaw Engineering & Construction Co., Ltd., Tel. (2) 88627
7.	Transformers	Soe Electric & Machinery Co., Ltd., Yangon, Tel. (1) 590 255 Yangon Transformer and Electrical Co.,Ltd, Tel. - (95 - 1) 511765, 514305
8.	Concrete poles for distribution lines	Sin Phyu Taw Co.,Ltd. (Mandalay), Tel. (95 - 2) 88529, Fax. (95 - 2) 53416 There are many factories in Yangon.
9.	Construction equipment	Myanmar Tractors, Yangon, Tel. (1) 541 717
10.	Fuel oil, lubricant oil	Olympic Co., Ltd., Yangon, Tel. (1) 211 430
11.	Erection of distribution lines	Myanma Electric Light Co-operative Society Ltd. (MELC), Yangon, Tel. (1) 227 678, There are many private companies. U Ye Neing, Lashio, Tel. 082-21344
12.	Manufacturing of rice husk gas engine	Myanmar Inventors Cooperative Ltd., Yangon, Tel. (1) 666 763

Source: Hearing by the JICA Study Team

Appendix-14 LIST of Myanmar Laws Relating To Environment

Administrative Sector

1. The Territorial Sea and Maritime Zones Law, 1977
2. The Emergency Provisions Act, 1950
3. The Essential Supplies and Services Act, 1947
4. The Police Act, 1945
5. The Poisons Act, 1919
6. The Explosive Substances Act, 1908
7. The Towns Act, 1907
8. The Village Act, 1907
9. The Yangon Police Act, 1899
10. The Explosives Act, 1887
11. The Penal Code, 1861 of Offences Affecting the Public Health, Safety, Convenience, Decency and Morals.

Agriculture and Irrigation Sector

12. The Plant Pest Quarantine Law, 1993
13. The Pesticide Law, 1990
14. The Embankment Act, 1909

Culture Sector

15. The Protection and Preservation of Cultural Heritage Region Law, 1998

City Development Sector

16. The Development Committees Law, 1993
17. The Mandalay City Development Law, 1992
18. The City of Yangon Development Law, 1990
19. (Amended in 1995 and again in 1996)
20. The Underground Water Act, 1930
21. The Water Power Act, 1927
22. The City of Yangon Municipal Act, 1922
23. (The Law Amending the City of Yangon Municipal Act, 1991)
24. The Yangon Water-works Act, 1885

Finance & Revenue Sector

25. The Myanmar Insurance Law, 1993

Forestry Sector

26. The Protection of Wild Life and Wild Plants and Conservation of Natural Areas Law, 1994
27. The Forest Law, 1992

Health Sector

28. The National Food Law, 1997
29. The Traditional Drug Law, 1996
30. The Prevention and Control of Communicable Diseases Law, 1995
31. The National Drug Law, 1992
32. The Union of Myanmar Public Health Law, 1972

Hotels and Tourism Sector

33. The Myanmar Hotel and Tourism Law, 1993

Industrial Sector

34. The Private Industrial Enterprise Law, 1990
35. The Factories Act, 1951
36. The Oilfield (Workers and Welfare) Act, 1951
37. The Petroleum Act, 1934
38. The Oilfields Act, 1918

Livestock and Fisheries Sector

39. The Animal Health and Development Law, 1993
40. The Freshwater Fisheries Law, 1992
41. The Myanma Marine Fisheries Law, 1990
42. (The Law Amending the Myanma Marine Fisheries Law, 1993)
43. The Law Relating to Aquaculture, 1989
44. The Law Relating to the Fishing Rights of Foreign Fishing Vessels, 1989
45. (The Law Amending the Law Relating to the Fishing Rights of Foreign Fishing Vessels, 1993)

Mining Sector

46. The Myanmar Gemstone Law, 1995
47. The Myanmar Pearl Law, 1995
48. The Myanmar Mines Law, 1994
49. The Salt Enterprise Law, 1992
50. The Land Acquisition (Mines) Act, 1885

Science and Technology Sector

51. The Science and Technology Development Law, 1994

Transportation Sector

52. The Highways Law, 2000
53. The Motor Vehicles Law, 1964
54. (The Law Amending the Motor Vehicles Law of 1964 enacted in 1989)
55. The Myanmar Aircraft Act, 1934
56. The Inland Steam Vessels Act, 1917
57. The Ports Act, 1908
58. The Defile Traffic act, 1907
59. The Yangon Port Act, 1905
60. The Canal Act, 1905
61. The Obstruction in Fairways Act, 1881

Source: Compiled by JICA Study Team

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2 Reports of U Aung, U Kyaw Min Htun, and Professor U Myat Thein in "Industrial Development in Myanmar: Prospects and Challenges" edited by T. Kudo, Institute of Developing Economics and Japan External Trade Organization, 2001

3 T. Kudo, "Myanmar", (Overseas Vocational Training Association, 1998, in Japanese)

4 A. Takahashi, "Agricultural Economy in Modern Myanmar" (Tokyo University Press, 2000, in Japanese)

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