# CHAPTER 4 DEVELOPMENT PLAN OF RICE HUST GAS ENGINE &BCS PROJECT

## BM-01 The Model Villages for Rural Electrification with Rice Husk Gas Engine and BCS

It is judged that the introduction of the rice husk gas engine being manufactured by a local cooperative since 1995 is appropriate for rural electrification in the paddy growing areas and in semi-urban areas with big rice mills. However, the use of the rice husk gas engine for rural electrification has only recently begun, and its operation by VECs is not yet well established. Therefore, it was deemed necessary to implement a model project to demonstrate the performance of the system to the public.

Therefore, lighting of Sama Lauk village by rice husk gas engine was presented in this chapter as one of three Development Plans.

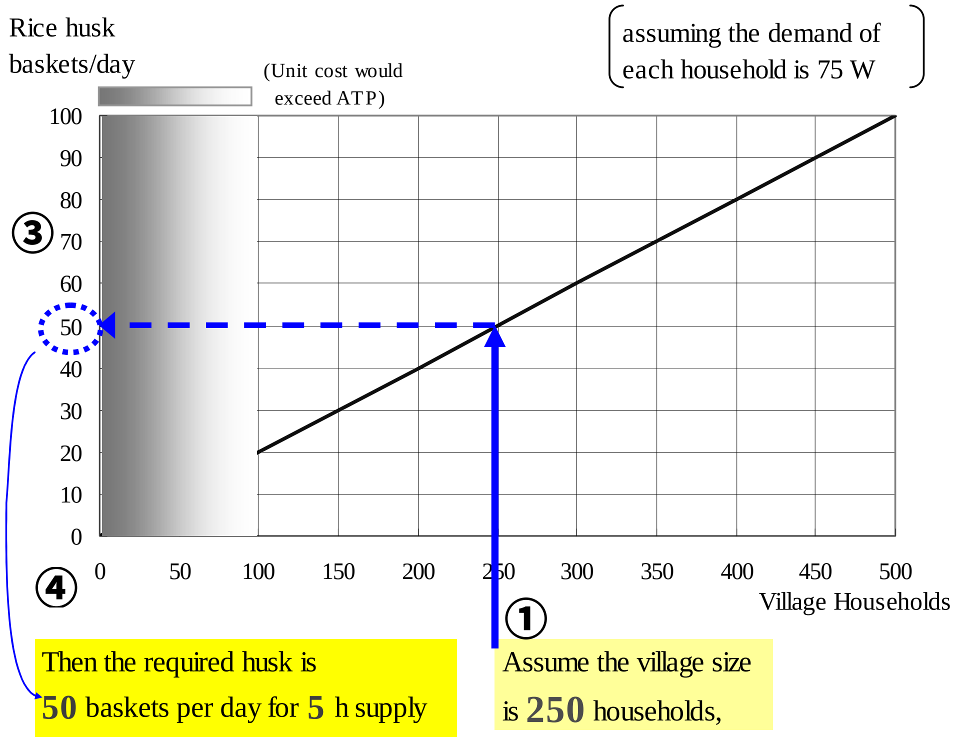
The rice husk gas engines implemented in Yonetalin village in Ayeyarwaddi Division and Panmati Village in Kachin State are attached in Appendix.

### 4.1 The Project Area

#### 4.1.1 Selection of Candidate Model Villages

Candidates for the Model Villages of electrification with rice husk gas engine were selected by site investigations conducted from September to December 2001 in Yangon and Ayeyarwady Divisions. Those townships that have large rice-mills were focused. The following are the main factors considered in the Model Village selection:

- ***Strong motivation of villagers for electrification***
  This is the most important factor for the proposed implementation of ***Village Schemes*** on self-help basis as well as for achieving the sustainable operation and maintenance.
- ***Availability of rice husk***
  The daily requirement of rice husk at a unit electricity demand of 75 W is shown in Figure 4.1.1.




Source: Assumed by JICA Study Team

**Figure 4. 1.1 Required Husk for Village Electrification with Gas Engine**

The amount of rice husk available in the village should be sufficient for year round power supply. Five baskets (25 kg) of rice husk as fuel corresponds to 1 gallon of diesel oil that can generate about 10 kWh. Assuming a unit power demand at 75 W per household, the requirement of rice husk for 250 households electrification would be 50 baskets (1 basket = 5 kg) for 5 hour lighting.

- ***Accessibility***

From the point of view of Model Village, it is important that villages have easy access from Yangon. Road conditions and distance from Yangon centre were given priority in the selection of the candidates villages for the accessibility of Government officers, NGOs, and other aid agencies who wish to inspect the Model Village electrification with rice husk gas engine even during rainy seasons.

- ***Ability to pay initial capital costs***

High inflation in Myanmar is a serious issue in managing a fund for supporting RE. It is also a great concern of borrowers (villagers) if they are imposed to pay an interest that can offset the inflation. The inflation will have less effect for a shorter loan period.

- ***Authority approval such as VEC, village chairman, and Township PDC***

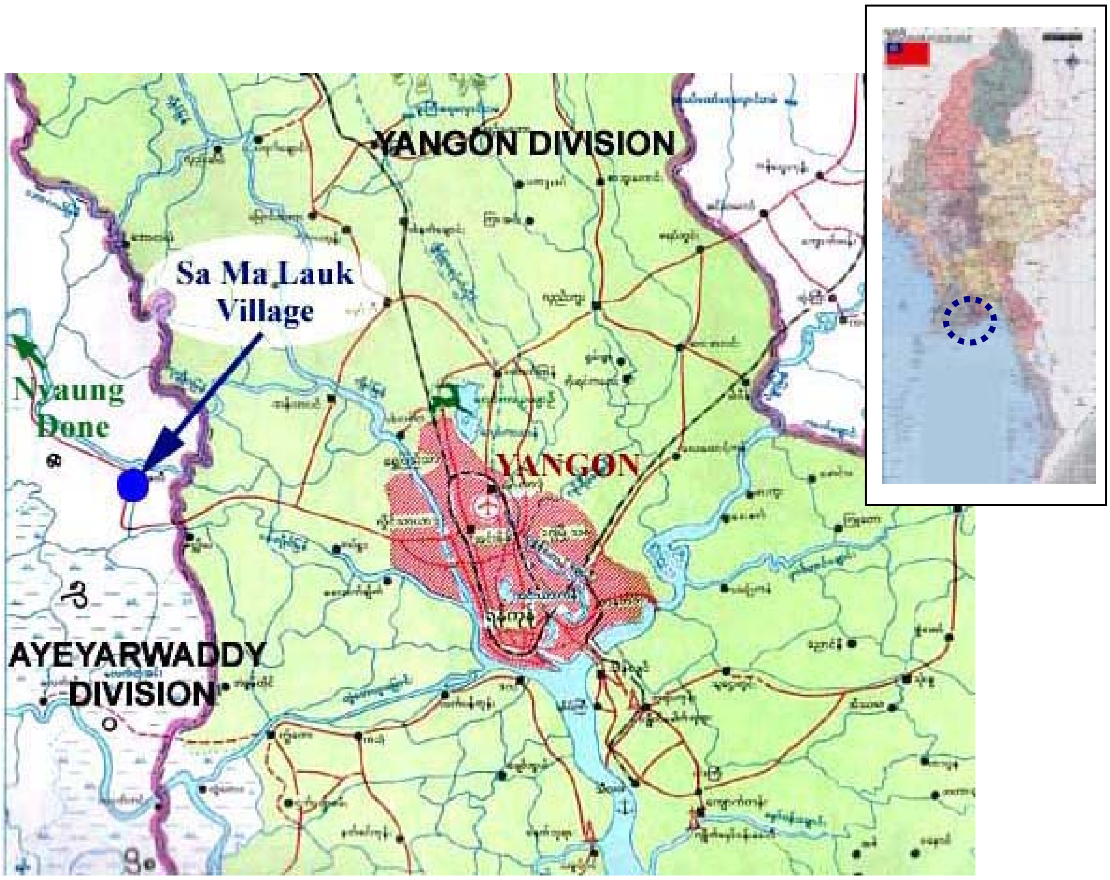
To implement ***Village Electrification Schemes, it is a precondition to obtain*** Village interviews were made in Than Lyin, Kyauk Tan, Thone Gwa, Hlae Gu, and Hmaw Bi townships in Yangon Division, and Hinthada and Nyaung Don townships in Ayeyarwady Division. In the Progress Report 1 prepared in November 2001, Kyain Seik (Than Lyin Township) and Banbwe Kone (Hmaw Bi Township) were initially selected to be the Model Villages. However implementation of these model villages was suspended due to the following reasons:

- The number of villagers who committed to join the VEC was only 23% (60 households of the total 277) in Kayin Seik village. Some questioned the performance of the husk gas engine that was not familiar to them. Many were unable to prepare the initial capital cost in the order of US$ 80-100 equivalent per household.
- Villager's consensus was not obtained in the two villages of Banbwe Kone to jointly set up a VEC.

In following the lessons above, two more villages were inspected; Pyin Ma Kan village (Thone Gwa Township) and Sa Ma Lauk village (Nyaung Don Township). Pyin Ma Kan has about 800 households and populations of over 4,000, and Sa Ma Lauk has 630 households and populations of more than 3,200. Both villages are eager to have electricity. It was considered that Pyin Ma Kan village was not very suitable as the Model Village since it was accessible by vehicle only during the dry season. Sa Ma Lauk Village was finally selected as the Model Village for electrification with rice husk gas engine.

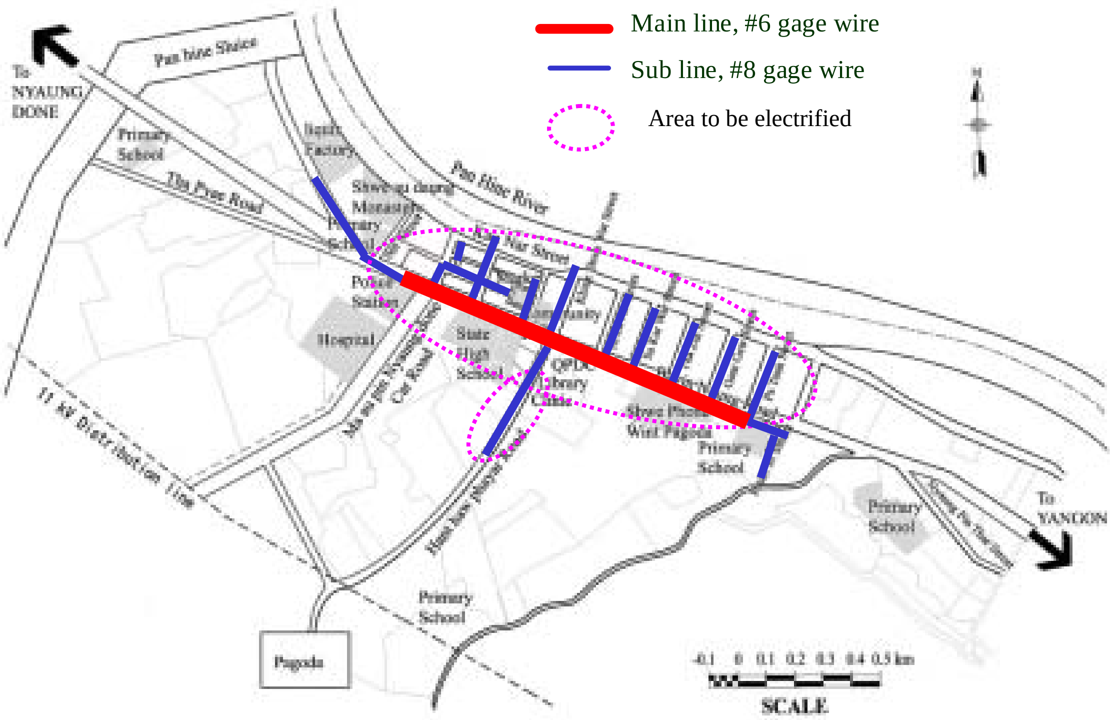
### 4.1.2 Features of the Model Village

Sa Ma Lauk is located approximately 50 km to the west of Yangon, along the Yangon-Pathein Highway near the border of Yangon and Ayeyarwady Divisons. It belongs to Nyaung Don township, Ayeyarwady Division. Sa Ma Lauk means "insufficient salt", as the production of fish in this village is so much that the salt supply cannot meet the demand. The main industry is cultivation of snake-head fish and paddy. This village is selected as a candidate for Model Village for electrification using a rice husk gas engine. The location is shown in Figure 4.1.2.




Source: JICA Study Team

**Figure 4.1.2 Location Map of Sa Ma Lauk**




Source: Drawn by JICA Study Team

**Figure 4.1.3 Sa Ma Lauk Village Map**

The area planned to be electrified in Sa Ma Lauk is shown in Figure 4.1.3. The central part of the village is located on the northern side of the Baying Naung Road (a main street of Sa Ma Lauk connecting Yangon and Nyaung Don) while public facilities such as the hospital, state high school, village office, library, clinic, pagodas, primary schools, etc., are on the southern side. The southern side appears to be blocked by the Bayin Naung Road from flooding of the Pan Hline River, a tributary in the Ayeyarwady Delta. The area of the village stretches about 3 km in the east-west direction and about 1 km width in the north-south direction. Central area where the distribution line is planned to be installed is about 1.3 km in the east-west direction and 0.2 km in the north-south direction. Another main road in the village is the Hant Gaw Phayar Road that branches off the main street beside the village office. The area along this street of 1.1 km long from the junction is also included in the area for electrification.

The basic information on Sa Ma Lauk village is as follows:

**Table 4.1.1 Basic Data on Sa Ma Lauk Village**

| Items | | Number | Remarks |
|---|---|---|---|
| Population | Household | 630 | |
| | Population | 3,241 | |
| Industry | Ice plant | 1 | One of rice mills and ice plant are powered by rice husk gas engine. |
| | Rice mills | 25 ton/day x 2,<br>1.5 ton/day x 2 | |
| | Oil mill | 1 | |
| | Liquor industry | 1 | |
| | Banana industry | some | |
| Public facility | Hospital | 1 | Contributed by the staff of Korean Embassy and NGO in Japan.<br>Already receiving power from MEPE Grid from a 315 kVA transformer. |
| | Primary schools | 5 | |
| | High school | 1 | |
| | Monasteries | 4 | |
| | VPDC office | 1 | |
| | Community Center | 1 | |
| | Post and Telecom | 1 | |
| | Police Station | 1 | |
| | Library | 1 | |
| Commerce | Fishery | many | |
| | Restaurants | many | Located along the highway |
| | Machine workshop for boats and cars | some | |
| | BCSs | 4 | Powered by diesel engine |

Source: Interview in Sa Ma Lauk by JICA Study Team

There are two rice mill stations in Sa Ma Lauk village. One of two rice mill stations was equipped with a rice husk gas engine RH-10 of MIC in March 2001 to power a rice-mill of 25 tons per day and an ice-mill. The other is equipped with a 25 ton/day rice mill powered by diesel engine. Accordingly, a sufficient amount of rice husk would be available for electrification of this village with rice husk gas engine.

Details of the existing rice husk gas engine RH-10 installed at the rice-mill in Sa Ma Lauk are as follows:

- 500 baskets per day of paddy (about 2,500 kg) can be processed at the 25 ton/day rice-mill powered by the rice husk gas engine RH-10 of MIC.

- The rice-mill operates for 12 hr/day and sometimes for 24 hours.
- The rice-mill consumed 1.5 gal/hr of diesel oil before the introduction of the RH-10 in March 2001. The diesel oil would have costed K342,000/month with a unit fuel consumption at 1.5 gal/hr and the current oil price at 900 K/gal for an operation of 12 hr/day and 20 day/month. The price for rice-milling was lowered from 80 K/basket to 40 K/basket while the other rice-mills continued to charge 60-100 K/basket. Nowadays, diesel oil is necessary only for starting the husk gas engine (1/4 gal per a start).
- The surplus of rice husk is sold at K10 per basket to a liquor factory in an industrial zone. The cost of husk transportation is K20,000 per truck.
- The maintenance works for the husk gas engine are:
    - Cleaning of tar trap which is placed just before the entrance to the engine, everyday;
    - Replacement of husk filter: primary filter everyday and secondary filter every other day;
    - Cleaning of primary purifier once a week and secondary once a month;
    - Replacement of engine oil and cleaning of spark plug (once every 45 days in the case of an RE in Younethaline village).

Information of public facilities in Sa Ma Lauk is as follows:

- The hospital in the village has an electricity supply from the MEPE Grid with a distribution transformer of 315 kVA and supply for 8 hr/day;
- The high school in the village was also planned to be electrified in November 2000, but it was not realized due to the cost of the distribution line which would be charged to villagers at K3,000,000.

Information of industries and commerce in Sa Ma Lauk is as follows:

- An existing BCS charges K100 for charging one 12 V battery and K50 for one 8 V battery. The charging capacity of the BCS is 20 batteries per day each of 12 V and 8 V batteries, in total 40 batteries a day. It uses 2 gal/day of diesel oil at K900/gal at present.
- Dried snake-head fish is one of the main industrial products and source of income in Sa Ma Lauk village, following the paddy production. Villagers cultivate the fish at the pond near the village. Dried banana is also produced. Drying does not need motors to be powered by electricity but lighting will gives villagers an increase in night work and further an increase in revenue.
- A liquor factory applied for MEPE electricity, but it has not been materialized due to the shortage of electricity.

- A private firm got a transformer of 500 kVA, connected to the MEPE Grid, to the east of the village. However, it has not started operation, reportedly due to power cuts.

Information of life of villagers is as follows:

- They spend K1,500-2,000 per month on lighting for the preparation of snake-head fish for drying under sunshine on the following day. One 8 W fluorescent light costs a family K500 per month.
- Charcoal is used for cooking at 600 K/bag and one bag is consumed in one month. Some are using rice husk for cooking and it costs 10 K per basket. Generally one basket of rice husk is consumed in one day.
- Lighting would be more expensive than cooking fuel.
- The average household owns 10-acres of land and the average income is K400,000 to K500,000 in Sa Ma Lauk.

Meetings were held among VPDC officials, the villagers, the MEPE township engineer, a REAM member, and an MIC engineer, pursuing village electrification with the rice husk gas engine. The villagers arrived at a consensus to implement the electrification in accordance with the concept of the Model Village. A VEC was then set up. Of the 630 households situated in the main part of the Sa Ma Lauk village, about 200 households would join the VEC at the preparation stage. It is expected that a significant part of the rest would also join the VEC to receive electricity after commissioning of the electrification system.

## 4.2 Needs and Demand for Electrification

The power demand of Sa Ma Lauk village is estimated as shown in Table 4.2.1.

**Table 4.2.1 Lighting Demand Forecast in Sa Ma Lauk Village**

| No. | Customer | Nos. | Unit consumption (W) | Upon Electrification with 200 h.h. Concur-rent use (%) | Upon Electrification with 200 h.h. RH-6 Estimated Power Demand (W) | After One Year with 500 h.h. Concur-rent use (%) | After One Year with 500 h.h. Estimated Power Demand (W) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Household | 200/ 500 | 75 | 70 | 10,500 | 70 | 26,250 | |
| Public Facilities | | | | | | | | |
| 2 | Hospital | 1 | - | - | 0 | - | 0 | Powered by the Grid |
| 3 | Primary schools | 3 | 380 | 0 | 0 | 0 | 0 | |
| 4 | High school | 1 | 600 | 0 | 0 | 0 | 0 | |
| 5 | Monasteries | 4 | 200 | 10 | 80 | 10 | 80 | |
| 6 | VPDC office | 1 | 200 | 5 | 10 | 5 | 10 | |
| 7 | Community Center | 1 | 200 | 20 | 40 | 20 | 40 | |
| 8 | Police Station | 1 | 100 | 50 | 50 | 50 | 50 | |
| 9 | Library | 1 | 200 | 0 | 0 | 0 | 0 | |
| 10 | Street Light | 100 | 20 | 40 | 800 | 100 | 2,000 | One per 5 household |
| | Sub Total | | | | 980 | | 2,180 | |
| Commerce | | | | | | | | |
| 17 | Fishery | many | 0 | 0 | 0 | 0 | 0 | |
| 18 | Restaurants | 5 | 100 | 50 | 250 | 50 | 250 | |
| 19 | Machine workshop for boats and cars | some | 0 | 0 | 0 | 0 | 0 | |
| 20 | BCSs | 1/4 | 1,000 | 80 | 800 | 80 | 3,200 | |
| | Sub Total | | | | 1,050 | | 3,450 | |
| **Total (including 5% distribution loss)** | | | | | **13,157** | | **33,474** | |

Source: Estimation by JICA Study Team

The power demand consists of the lighting demand of households and public facilities, including streetlights. Assuming three 20 W lights per household and one 60 W TV per four households (or one 15 W radio per household), the average household demand will be 75 W. The lighting demand would be about 13 kW upon commissioning with about 200 households. It is anticipated to increase to about 33 kW within one year with the additional 300 members joining the VEC (500 households in total). Under these circumstances, The household electrification ratio would reach 80% (= 500/630).

Since the proposed electrification will be realized with rice husk gas engine, it is planned that the electricity will be supplied only for 5 hours from 18:00 to 23:00. In the future, it may also be operated in the daytime to supply to public facilities.

Power supply to the industrial sector during the daytime was not planned in this Model Village with the rice husk gas engine because:

- The gas engine could not respond to quick changes in the load and its power capacity may be limited to about 50 kW in the net output of generator.

- The gas engine system will require a greater husk supply, frequent maintenance works, and spare parts.
- When machine breaks down and needs a significant amount of money for repair or replacement, there may be conflicts regarding the cost allocation.
- Management of the small electricity business by the VEC will be complicated because of involvement of the industrial sector who pursues its own interest, and the sustainable operation of the RE system would face difficulty.

Accordingly, it is planned that the village electrification system with the rice husk engine should be operated to provide light for households, public facilities including streetlights, and BCS. Some commercial facilities such as restaurants, Karaoke-shops, and video-shops may be regarded as semi-public facilities where power supply would be made from the village electrification system.

For the industrial sector, it is recommended that they should have and use their own diesel or husk engines as power sources until the Grid connection is realized.

In the case of Younethaline village, Ayeyarwady Division where a rice husk gas engine was introduced in April 2001 under the leadership of DPDC, electricity is also provided during the daytime, but only for two days a week for power supply to school. It is possible to adjust the operating hours of the engine according to the demand, amount of available rice husk, and engine condition.

## 4.3 Development Concept

***Objectives***

The objectives of the Model Villages are:

- To test and monitor the implementation, O&M, and management of ***Village Scheme*** by VEC on a self-help basis with support from an NGO in order to best-adapt the RE with husk gas engine to the paddy cultivating villages in Myanmar;
- To demonstrate what can be achieved with rice husk engine, both to villagers, who may pass by the Model Villages on their way to and from Yangon, and to officers of the Government, aid agencies, and NGOs concerned with rural electrification;
- To try and test the proposed concept of Micro RE Fund through the operation and management of the Model Villages.

***Project Components***

In order to achieve the objectives above, the following projects will be implemented:

- One Model Village for rural electrification will be implemented and managed by VEC near Yangon with rice husk gas engine and BCS.
- The rice husk gas engine will electrify those households that are located in the central part of the village within about 1,000 m cable distance from the engine-generator. The electricity generated will be supplied to each household by 230 V distribution lines. The engine generator may be operated twice a day at:
    - Prime operation: 5 hours from 6:00 p.m. to 11:00 p.m. mainly for household lighting
    - Secondary operation: 6 hours from 9:00 a.m. to 3:00 p.m. mainly for school lighting and battery charging at BCS

  It needs further examination if the schools and BCSs should have an exclusive distribution line from the generator in order to limit the daytime power supply only to those public facilities, or whether all households should have the chance to receive power also during the daytime.
- One set of line-fed BCS will be provided to charge batteries for those villagers who are living in houses scattered in the peripheral zones surrounding the village center.

- In order to arrange the initial capital costs required for subsequent ***Village Schemes*** in the future, a seed money concept of micro RE Fund will be studied through implementation of the Model Village:
  - An NGO will apply for a grant.
  - With the grant the NGO will procure and install a husk gas engine-generator set and distribution lines, etc.
  - The villagers will save and deposit money equivalent to the initial capital costs on a 3-year installment basis.
  - The money saved by the villagers would be contributed and deposited in the bank account of the Micro RE Fund and would be used as part of the revolving fund for the electrification of other villages.
- The NGO will monitor the implementation, test operation, and management of the Model Villages by VEC preferably for three years.

***Principles for Implementation of Village Schemes***

- The Model Villages are to demonstrate the performance and effectiveness of the ***Village Schemes*** with rice husk gas engine and BCS:
  - setting up of VEC;
  - planning of village electrification by VEC;
  - implementation with the assistance of NGO;
  - operation and maintenance of the village power supply system including collection and storage of rice husks;
  - management of the power supply business for sustainable operation, saving for the future maintenance and replacement of the engine, and improvement of the power supply conditions, and so forth.
- VEC consists of the representatives desiring for electrification schemes and plays a role as follows:
  - data collection of population, number of residences, revenue, current situation in use of electricity, which will be a basic data for planning of electrification schemes and application of subsidiaries;
  - planning for area of electricity distribution, capital collection of initial investment, determination of electricity tariffs, repayment for soft loan, if any, etc.;
  - collection of electricity tariffs and accounting for repayment of soft loan, payment of salaries to operators, procurement of O & M equipment and spare parts, etc.;

- securing of human resources such as VEC members, staff of operation, maintenance and management, accountants, etc.;
- securing of rice husk and stockyards, and lands of powerhouse construction;

- NGO takes charge of the following:
  - planning for selection of the villages to be electrified, schedules, demand forecast, investigation of village society, etc.;
  - achievement of approvals from the concerned authorities such as VPDC, TPDC, MEPE temples, etc.
  - assistance in establishment of VEC and preparation of proposals for stipulations of VEC;
  - securing of budgets for cost of facilities, and that of operation, maintenance and management.
  - coordination between VEC and the contractors for powerhouse construction, supply of gasification plants and generating equipment, and erection of distribution lines;
  - training of staff of operation, maintenance, and management;
  - monitoring and reporting;
  - supply of information for other villages which desire electrification.
- In order to support and promote the ***Village Schemes*** that should be implemented in the future following the Model Village, it is desirable that a Micro RE Fund provide a short-term loan to cover the capital costs tentatively. The Fund is a private fund to be sponsored by contributions from the various private organizations, people, and villagers already electrified.
- The costs and expense of the supports and services provided by NGOs would be borne jointly by NGOs, the Fund, and other supporting facilities such as CEP provided by JICA. In respect of operation of the Fund and repayment of loan, the following are to be taken into account:
- In order to stimulate the villagers' motivation to achieve early repayment or saving for the initial capital costs (the early repayment will save the Fund to survive even under certain inflation and to support electrification of other villages), the concept similar to interest may be introduced. For example, no interest will be imposed on the part of the capital repaid within the first year. An interest rate of 10%, for example, will be imposed for those capital not

repaid within the first year. This will increase to 20% for capital not repaid within the second year.

- The devaluation of the capital costs due to inflation in excess of the nominal interests above need to be covered by the Fund.
- The villagers shall make another savings for future maintenance and replacement, which would cost at about 15% of the initial capital costs within several years from the commissioning.
- It is desired that the villagers also make some contributions after completion of the repayment of the minimum capital allocated to them unless it is a grant scheme.
- In respect of customers, i.e. villagers, the following are to be studied and examined:
  - All the capital costs of the husk power plant and distribution lines including the cost of house-connection and in-house wiring, shall be borne by the villagers in the spirit of self-help.
  - The costs of BCS shall be covered out of the charging fee. However, it cannot be fully recovered by the charging fee in the first 3 years. Monthly sales would be about K10,000. After deducting costs for the shop and operators, the monthly net saving would be in the order of K5,000. The rest of the BCS costs needs external contribution either by VEC or by the Fund.

***Issues of Village Schemes***

- According to a cost estimate, the total capital costs per household would be K54,000 (RH-15 for 500 households) to K75,000 (RH-6 for 200 households). This may exceed the ability to pay of villagers but the wealthy.
- The countermeasures for the subsequent ***Village Schemes*** may be:
  - Share of the capital costs by the commercial users in the village such as video shop, Karaoke shop, etc. (including contribution from monthly sales);
  - Special contribution from villagers (for power house, storage, streetlights, support poles, etc.), volunteer labor and offering of materials by villagers contribute to saving of initial investment.

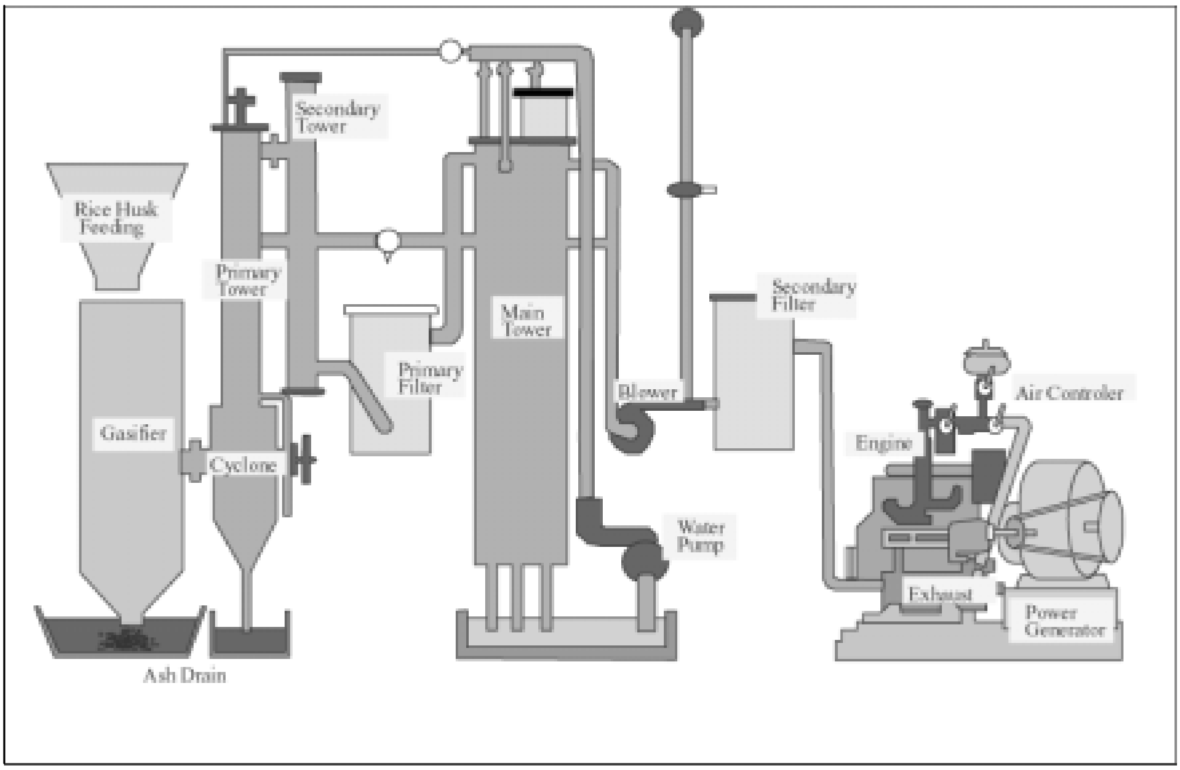
- A study is needed on:
  - regulations relating to the operation and management of the Fund;
  - regulations on village electrification and the need for approvals from authorities concerned.
- Regarding securing fuel and land of powerhouse construction, further studies are needed on:
  - Agreement with rice-mills to supply rice husks free of charge or at a certain affordable price;
  - Collection and storage of rice husks for the two low milling months of September and October in particular;
  - Land for the power-house and storage;
- How to secure repayment of the loans except for a grant scheme:
  - to have collateral from members of VEC;
  - to make the generator set as collateral;
  - to seal the gas engine generator set.

## 4.4 Basic Design and Cost Estimate

### 4.4.1 Profile of Husk Gas Engine

The system for rice husk gas engine designed by MIC is illustrated in Figure 4.4.1

- **Gasifier**: Husk is retorted in the gasifier. Combustible gases are produced by complex reaction such as partial combustion, reduction, and pyrolysis. Air is introduced downward from the top of the gasifier.
- **Ash drain**: Ash is drawn off from the bottom of the gasifier and collected in water.
- **Cyclone**: Dust of ash is separated by centrifuge.
- **Primary, secondary, and main purification Tower**: Ash and hydrophilic tar is trapped by water drip.
- **Primary and secondary filter**: Rice husk is used for absorption of tar and dust contained in the gases. Husk for filtering is renewed everyday and the used husk is fed into the gasifier.




Source: MIC (Myanmar Inventors Cooperative) catalogue, arranged by the JICA Study Team

**Figure 4.4.1 Rice Husk Gasification and Engine-Generator System**

In order to meet the forecast demand as presented in Table 4.2.1, a model RH-6 would be sufficient to supply power for the electrification of about 200 households at the beginning. However, it is anticipated that within one year of the commissioning most of the non-electrified households in the central part of the village would also wish to have power supply. To meet such demand for electrification, a model RH-15 was selected for installation in the Sa Ma Lauk village.

### 4.4.2 Cost Estimate

The costs of the rice husk gas engine system for Sa Ma Lauk was estimated with reference to the quotation of MIC, the distribution line costs, and the costs of existing husk powered schemes. The cost estimate is summarized in Table 4.4.1.

**Table 4.4.1 Capital Cost Estimate for Sa Ma Lauk**

| | Initial Costs for 200 h.h. RH-6, 60 PS | | Total Project Costs RH-15, 150 PS | |
|---|---|---|---|---|
| | **Kyat** | **USD*4** | **Kyat** | **USD*4** |
| Gasifier, engine and generator set, including<br>Installation<br>Basement & building<br>Husk storage<br>Fencing | 5,427,000 | $8,349 | 11,832,000 | $18,203 |
| Distribution line gage #6 *1 | | | 5,720,000 | $8,800 |
| Distribution line gage #8*2*3 | 9,413,000 | $14,482 | 7,215,000 | $11,100 |
| Streetlight | 160,000 | $246 | 302,000 | $465 |
| BCS facilities & battery workshop | - | - | 2,000,000 | $3,077 |
| **TOTAL** | **15,000,000** | $23,077 | **27,069,000** | $41,645 |

*1 Assumed at 8,800$/km. 1.0km x 8,800$/km x 650 Kyat/$ = 5,720,000 Kyat
*2 Assumed at 3,000 $/km. 3.7km x 3,000$/km x 650Kyat/$ =7,215,000 Kyat, for overall Project
*3 590 Kyat/ft x 16,000 ft = 9,440,000 Kyat. *4 at exchange rate US$ 1.00=K650, Dec 2001

Source: Estimation by JICA Study Team

The total capital cost was estimated at about US$ 42,000 for an RH-15 having an engine capacity of 150 PS that would meet the total lighting demand of the village.

The costs of engine and generator, basement and building, and husk storage are dependent on the engine capacity. Installation cost is about 20% of the engine and generator costs. The length of the distribution line in Sa Ma Lauk village is 1.0 km for the main line and 3.7 km for the branch lines. The distribution line cost for the initial supply to 200 households was estimated assuming application of wire gauge #8 to all the 4.7 km long line section (left side in Table 4.4.1). However, to facilitate power distribution also to the additional 300 households who would join VEC within one year from the commissioning, the main line of 1.0 km long by the Bayin Naung Road should be at least of wire gauge #6.

A BCS is important for the people who cannot receive power by distribution lines due to long distance from the generator or who cannot afford to pay the initial capital costs. The low cost of battery charging will directly benefit the BCS users. There are four BCSs operating in Sa Ma Lauk village. These need improvement to ensure a longer lifetime for batteries, such as a parallel charging controller.

The initial capital cost is approximately $80-110 per household.

## 4.5 Economic, Financial, and Environmental Aspects

### 4.5.1 Financial Plan

The capital costs of the Model Villages are assumed to be managed with grant facilities from EOJ and JICA. Figure 4.5.1 shows the existing financial facilities of GOJ.

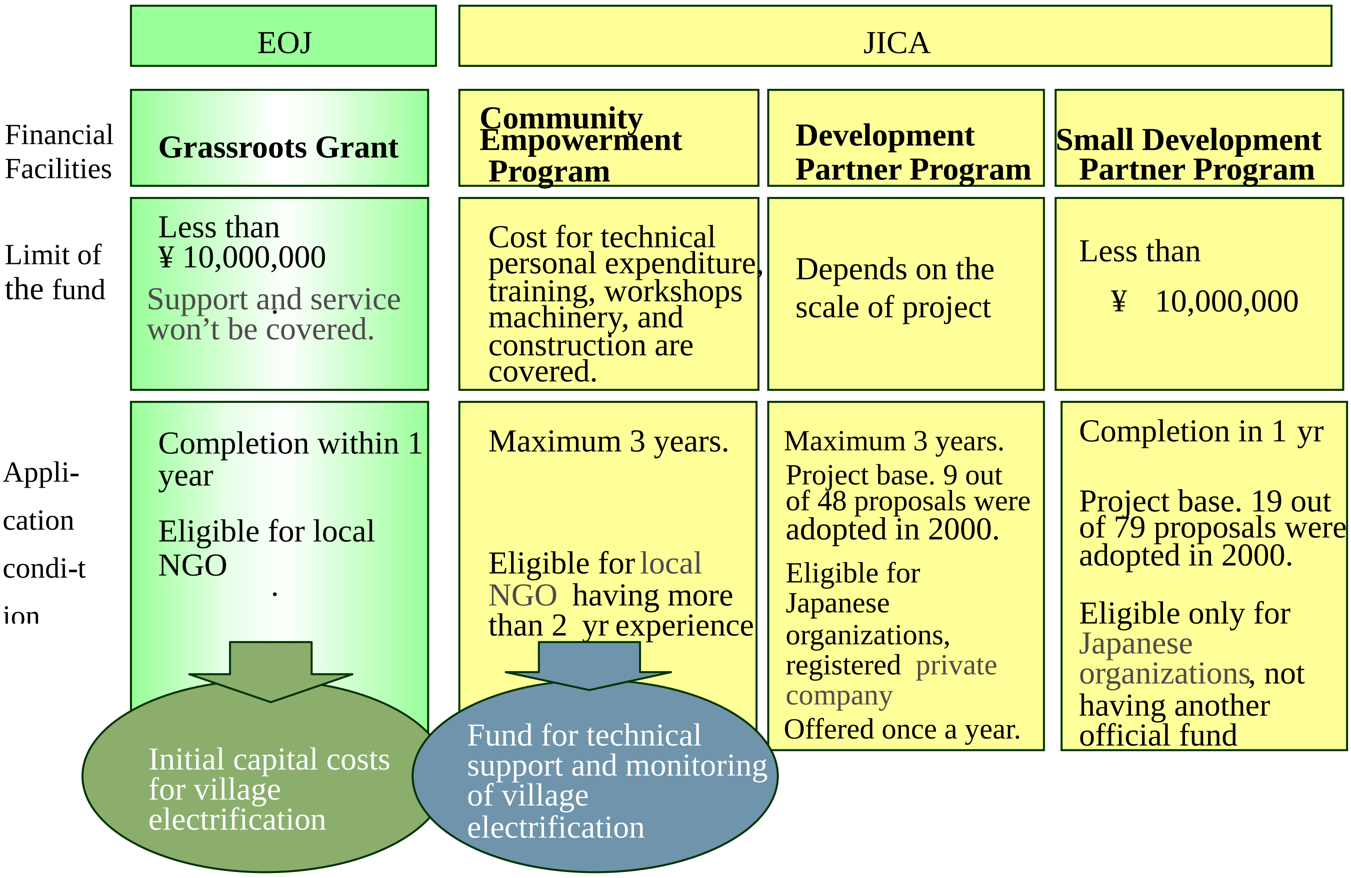



**Figure 4.5.1 Features of Available Financial Facilities of Japan**

EOJ provides Grassroots Grant to NGOs and other organizations such as hospitals, schools, and local authorities for development projects. The assistance covers only capital costs. Services and administrative costs are not supported by this grant. On the other hand, Community Empowerment Program (CEP) provided by JICA finances not only small equipment and works but also technical services. It basically supports only local NGOs having more than two years experience. EOJ receives application for Grassroots Grant at any time while JICA receives application for CEP once a year in August.

The concept of revolving RE fund for promotion of ***Village Schemes*** succeeding to the Model Village is shown in Figure 4.5.2 and is described below:

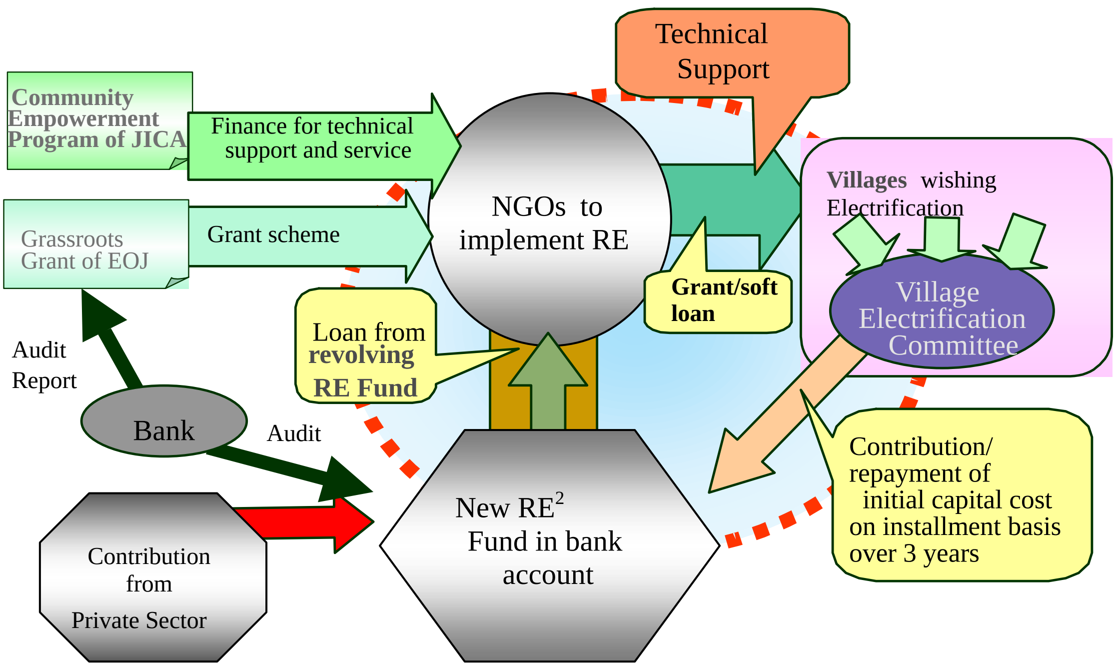
1) NGO to receive a financial support and technical services from CEP or similar, and for capital costs from Grassroots Grant or proposed RE Fund in the future.

2) NGO to prepare an agreement with VEC for the implementation with grant from EOJ or soft loan from the RE Fund. A loan repayment plan is to be prepared in the case of soft loans. NGO provides technical support to VEC for the implementation and initial O&M.

3) VEC to contribute/repay the initial capital cost on an installment basis to the bank account of "Rural Electrification with Renewable Energy Fund ($RE^2$ Fund)" based on the agreement with NGO.

4) The bank account of $RE^2$ Fund will provide a revolving fund and can provide soft loans for the other villages who wish electrification following the Model Villages.

5) Bank audits the money flow of the $RE^2$ Fund.




Source: JICA Study Team

**Figure 4.5.2 Concept of Micro RE Fund for Supporting Village Schemes**

### 4.5.2 Economic Aspects

Households, public facilities, and some commercial facilities such as BCS and restaurants will benefit from the planned electrification. Without the project, the only comparable source of electricity is diesel generator. The price of diesel oil is increasing year by year. It rose from 175 K/gal to 900 K/gal over the past six years. Assuming the annual inflation rate is 25%, the price would be K534 now, but the actual price is 1.7 times higher, that is, the cost for diesel oil has increased 1.7 times compared to the price of other commodities.

Rice husk, used as alternative fuel, is domestic resources. Unlike fossil fuels, it would not be affected by international economic conditions.

**Table 4.5.1 Annual Operation Costs**

| Operation cost | Monthly | Yearly |
|---|---|---|
| Gasifier and engine operator | 30,000 | 360,000 |
| BCS operator | 15,000 | 180,000 |
| Technical assistant | 9,000 | 108,000 |
| Rice husk | 30,000 | 360,000 |
| Power distribution checker | 6,000 | 72,000 |
| TOTAL | 90,000 | 1,080,000 |

**Table 4.5.2 Annual Maintenance Costs of RH-10**

| Parts | nos or set | Yearly |
|---|---|---|
| Gasifier | | |
| Ash release shutter | 2 | 3,420 |
| Water pump ball bearing | 2 | 1,800 |
| Ball house set | 2 | 5,400 |
| Gear parts | 2 | 9,000 |
| Blower ball | 1 | 4,200 |
| Pulley belt | 2 | 13,320 |
| Gunny bag filter | 24 | 2,400 |
| Gasifier Sub TOTAL | 39,540 | |
| Engine | | |
| Piston ring | 1 | 60,000 |
| Spark plug | 6 | 4,200 |
| Coil wire | 1 | 16,000 |
| Engine oil | 4gal x 12 | 86,400 |
| Engine oil filter | 144 | 172,800 |
| Engine overhaul | 1 | 90,000 |
| Engine Sub TOTAL | 429,400 | |
| TOTAL | 468,940 | |

Power consumption in Sa Ma Lauk would be 33 kW x 5 hour/day x 365 day/year = 60 MWh. Assuming 1 gal of diesel oil can generate 10 kWh of electricity, 6,000 gal of diesel oil, that is 6,000 gal x 900 K/gal = K5,400,000 (equivalent to US$8,300) will be saved in terms of energy cost.

The operation and maintenance costs would be in the order of K1.8 million annually. The breakdown is shown in Table

s 4.5.1 and 4.5.2. The maintenance costs of the gasifier and engine were assumed in Table 4.5.3 as 1.5 times the net estimates from Table 4.5.2.

**Table 4.5.3 Annual O&M Costs**

| | |
|---|---|
| Operation costs | 1,080,000 |
| Gasifier maintenance | 59,000 |
| Engine maintenance | 644,000 |
| TOTAL | 1,783,000 |

Source: Estimated by JICA Study Team (Table 4.5.1~3)

The annual economic benefit may be assessed as the balance of the fossil fuel saved by using rice husk and the O&M costs calculated above, assuming the capacity costs of both the diesel generator and husk gas engine are of the same order:

K5,400,000 - K1,783,000 = K3,617,000

equivalent to US$5,600 per year in village total and US$11 per year per household.

It is desirable to share the economic benefit above with the villagers who will not participate in the electrification, due to an inability to pay the initial capital costs. In this context, two programs will be provided. One is streetlights, which can be shared by all the villagers. The other is battery charging at BCS to be powered by the husk gas engine. Battery charging fees at BCS could be reduced as has been realized in the milling charge of the husk-powered rice-mill, since the fuel cost of the diesel generator will be avoided or significantly lowered using husk-engine. The reduced cost of BCS contributes especially for the poor.

### 4.5.3 Financial Aspects

If the Model Village is totally financed by the Grassroots Grant of EOJ, no repayment will be required for the villagers except for O&M costs and voluntary contribution to the Micro RE Fund.

A repayment plan of the capital costs is worked out as a sample for a case of initial costs for electrifying the first 200 households as shown in Table 4.5.4 and 4.5.5. If the repayment is to be completed in one year, K15,000,000 in total for the village or K75,000 per household should be repaid. However, most of the households cannot afford to pay this amount within one year. As an incentive measure for promoting early repayment, a concept similar to interest is introduced and proposed. An interest rate of 10% will be charged on the capital unpaid after the first year, and 20% for the capital unpaid after the second year. If they repay within two years, the total repayments will be K15,750,000, and K17,000,000 after three years.

**Table 4.5.4 Village Repayment Option for Initial 200 hh**

| | | Repayment Period (Year) | | |
|---|---|---|---|---|
| Year | Interest Rate | 1 | 2 | 3 |
| 1st | 0% | 15,000,000 | 7,500,000 | 5,000,000 |
| 2nd | 10% | | 8,250,000 | 6,000,000 |
| 3rd | 20% | | | 6,000,000 |
| **TOTAL** | | **15,000,000** | **15,750,000** | **17,000,000** |

**Table 4.5.5 Household Repayment Option for Initial 200 hh**

| | | Repayment Period (Year) | | |
|---|---|---|---|---|
| Year | Interest Rate | 1 | 2 | 3 |
| 1st | 0% | 75,000 | 37,500 | 25,000 |
| 2nd | 10% | | 41,250 | 30,000 |
| 3rd | 20% | | | 30,000 |
| **TOTAL** | | **75,000** | **78,750** | **85,000** |

Source: Estimated by JICA Study Team (Table 4.5.4~5)

Table 4.5.6 shows an example for the shared repayment of the initial capital costs according to the income level of villagers. It would match the Myanma culture and it would be reasonable for the villagers that those who are better-off will pay more. In the table below, households of different income level are divided into three groups. An adjustment coefficient could be applied so that one household of the High Income Group would pay two times the Middle Income Group and four times the Low Income Group, for example. In this table, the coefficient of 0.13 for High Income Group means that this Group will share 13% of the total capital costs. The numbers of household in each group and the coefficient should be adjusted by VEC after social research of the participants.

**Table 4.5.6 Sample Repayment per Household by Income Group (200hh)**

| Group | Nos. of hh | Coefficient | Amount per hh | 1st year | 2nd year | 3rd year |
|---|---|---|---|---|---|---|
| High | 10 | 0.13 | 195,000 | 65,000 | 78,000 | 78,000 |
| Middle | 75 | 0.50 | 100,000 | 33,333 | 40,000 | 40,000 |
| Low | 115 | 0.37 | 48,261 | 16,087 | 19,304 | 19,304 |
| **TOTAL** | **200** | **1.00** | **15,000,000** | | | |

**Table 4.5.7 Income from Monthly Charge from Users**

| Usage | nos. | Charge (Kyat) | Total fee (Kyat) |
|---|---|---|---|
| In-house | 200 | 600 | 120,000 |
| Street Light (included in the above) | | | |
| Battery in BCS | 1,200 | 40 | 48,000 |
| Commercial Use | 15 | 1,800 | 48,000 |
| Total Income/month | | | 216,000 |
| Total Income/year | | | 2,592,000 |

Operating income is simulated in Table 4.5.7. As calculated in Table 4.4.1, the total capital cost of the Project would be about K27 million, while the repayment from the initial 200 villagers would remain at K15 million. In such case, a subsidy or soft loan from the Micro RE Fund would be needed to cover the difference. The subsidy of about K12 million (see Table 4.5.8), if provided by the RE Fund, may be recovered as the initial connection fee (at or higher than K40,000 per h.h.) from those 300 households who would join the VEC after the commissioning.

**Table 4.5.8 An Option for Capital Cost Arrangement**

| | |
|---|---|
| (1) Initial connection fee from the first 200 h.h. | 15,000,000 |
| (2) Initial connection fee from additional 300 households if any in the future, initially to be susidized or provided as loan | 12,069,000 |
| (3) Total capital cost of the Project | **27,069,000** |

Source: Estimated by JICA Study Team (Table 4.5.6~8)

The order of operating surplus is estimated as the balance of operating income given in Table 4.5.7 and O&M costs in Table 4.5.3. The annual operating income is estimated at K2,592,000 while the O&M costs at K1,783,000. The annual operating surplus would be in the order of K800,000. This should be deposited as a fund for future maintenance and replacement of the equipment.

Consumption of the power per household would be:

75 W x 0.75 x 5 hour/day x 30 days/month = 8.4 kWh/month

The monthly tariff would be in the order of K600 per household per month. The unit price would be about 71 K/kWh or about 0.11 $/kWh, which is much higher than the current tariff of MEPE at 2.5 K/kWh.

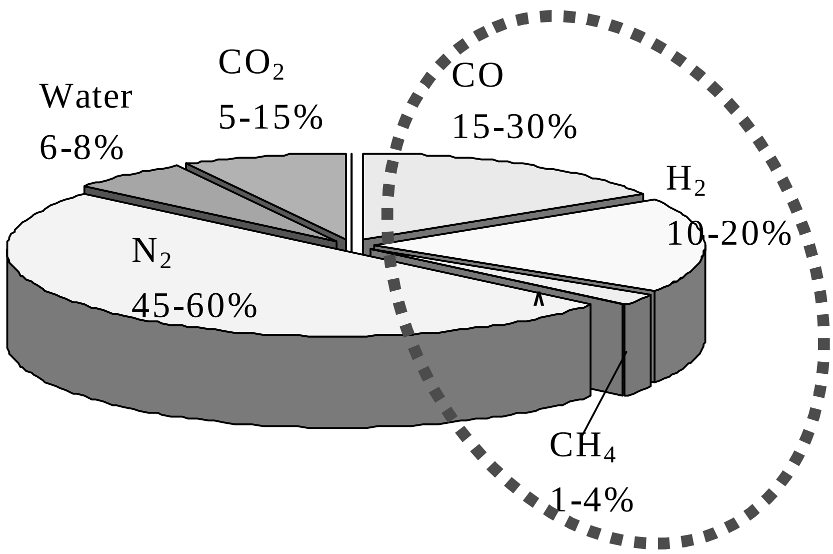
### 4.5.4 Environmental Impact

**(1) Gases**

The gas has to be considered for its environmental impacts at two stages. One is called “producer gas”, that is a fuel gas for the combustion of the engine produced from rice husk in the gasifier. The other is exhaust gas, which is released after combustion in the engine.

1) Producer gas

Combustible gases are generated from rice husk as a result of complex reaction of pyrolysis, incomplete combustion, and reduction. Figure 4.5.3 shows the general constituents of gases produced from biomass[1)]. Producer gases contain a large amount of carbon monoxide, which is extremely toxic and dangerous as it combines with haemoglobin in the blood preventing oxygen absorption and distribution. There is little chance of gas leakage during operation as the




Source: “Biomass Gasification”, ARTES Institute, Univ. of Flensburg

**Figure 4.5.3 Constituents of Producer Gas in Rice Husk Gas Engine)**

gasification system works under suction but it is essential that the air is kept well ventilated in the powerhouse.

2) Exhaust gas

There is no impact on global warming by biomass combustion since the organic components of biomass are produced by photosynthesis from carbon dioxide. The balance of carbon dioxide is neutral. The emission of $CO_2$ by the diesel engine is 3.14 (Mt-$CO_2$/Mtoe) or 0.856 (Mt-C/Mtoe). The calorific value of diesel oil is 10,167 kcal/kg, and the consumption of diesel oil per kWh would be 0.204 l/kW. Assuming the annual power consumption is 82,125 kW as discussed in Sub-section 4.5.2, the emission of $CO_2$ is estimated as 82,125 kW x 0.204 l/kW x 0.84 kg/l x 0.856 (Mt-C/Mtoe) = 12 tons of carbon equivalent, when diesel oil is used for the electric power. $CO_2$ of 44 tons of carbon dioxide equivalent would be saved annually by the introduction of a rice husk gas engine in the case of Sa Ma Lauk village electrification.

As the sulfur content of rice husk is lower than 0.1%, the exhaust of sulfur oxide ($SO_x$) from husk is supposed to be less than 10% of that of diesel oil. On the other hand, rice husk contains about 2% of nitrogen in organic forms, which is much higher than that of fossil fuels. As the reaction in the gasifier is held below the lowest temperature required for the formation of $NO_x$, no fuel-$NO_x$ is expected to be contained in the producer gas. The organic nitrogen component is supposed to be decomposed to $N_2$, reduced to $NH_3$, or remained into the tar. The exhaust gas from the engine after combustion of producer gas should have less $NO_x$ that emitted from diesel oil generation, as partial pressure of nitrogen in producer gas is smaller than that of the air.

Dioxin emission is not expected for two reasons. First, the chlorine component of rice husk is quite low, less than 0.01%. Second, the temperature of both gasification and combustion is too high for the production of dioxin and its derivatives. However, it can not be said that there is no possibility for the formation of chlorine compounds during the increasing and decreasing temperature phases of the gasifier. Therefore it is proposed to monitor the detailed constituents of the exhaust gases from rice husk gas engines by gas chromatography or other analytic equipment for further detailed evaluation of the environmental impacts.

### (2) Analysis of tar and ash

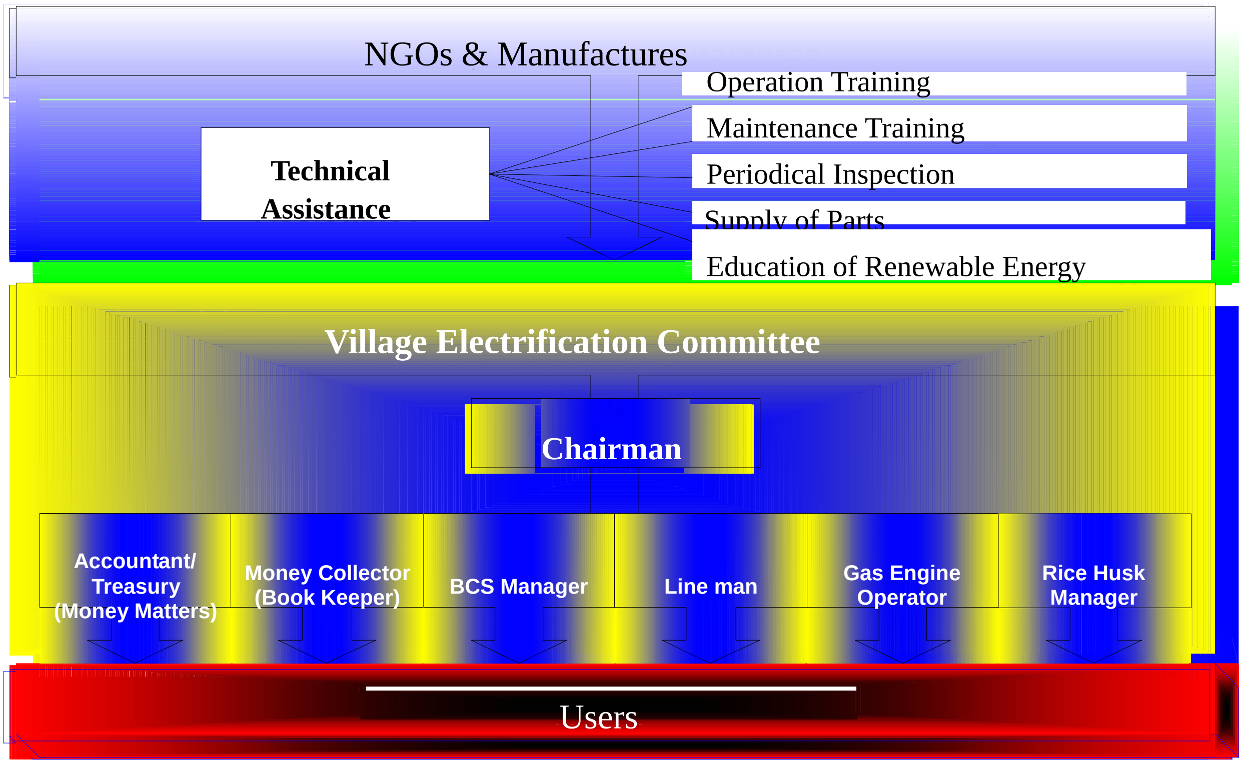
It is necessary for evaluation of environmental impact to have a quantitative and qualitative analysis of the by-products. Without water content, tar contains 0.07% total sulfur, 0.44% total nitrogen, 0.004% total chlorine, and less than 0.01% ash and mineral. The calorific value of tar after removing water is 31 to

33 MJ/kg. The tar can be used as fuel according to analysis made by the Institution of Agricultural Machinery in 1992[2)]. The constituent of husk tar is supposed to have aromatic, branched, and cyclo-compounds which may be difficult to be biodegraded. The tar has pH of 3.4, indicating a weak acid, and has a potential to corrode containers. It is presumed to come from the oxidation of polysaccharide. It is preferable for the treatment of waste water containing ash and tar to be neutralized with alkali such as lime to minimize the harm to the natural environment.

Ash content depends on the condition of combustion. As the qualitative component of ash and tar is still unclear, further analysis is suggested to be performed by a method such as liquid chromatography-mass spectrometry (LC/MS), gas chromatography-mass spectrometry (GC/MS), and Fourier-transform infrared spectrometry (FT-IR).

## 4.6 Organization for O&M

The organization for O&M has three levels (see Figure 4.6.1). They are NGOs & manufacturers, VEC, and the users. Among these three, the official responsibility and implementation of O&M belongs to VEC. NGO and the manufacturers are responsible to assist them especially on technical matters. The technical know-how from the upper level is expected to spread among the users through VEC.




Source: JICA Study Team

**Figure 4.6.1 Operation and Maintenance for RE by Rice Husk Gas Engine**

## 4.7 Tariff System and Accounting

### 4.7.1 Tariff System

The tariff system of Rice Husk Gas Engine & BCS project can be similar to the existing community self-supply system.

There are number of cases where RE was financed by donation or by the community through a village electrification committee. In most of these cases they could not afford to install meters. Therefore they could not use the kWh consumption-based charging system. Instead, in most of the villages surveyed, they charge by the type and numbers of appliances.

The tariff system should preferably be based on the willingness to pay. The monthly charge for lighting could be at least one dollar per household.

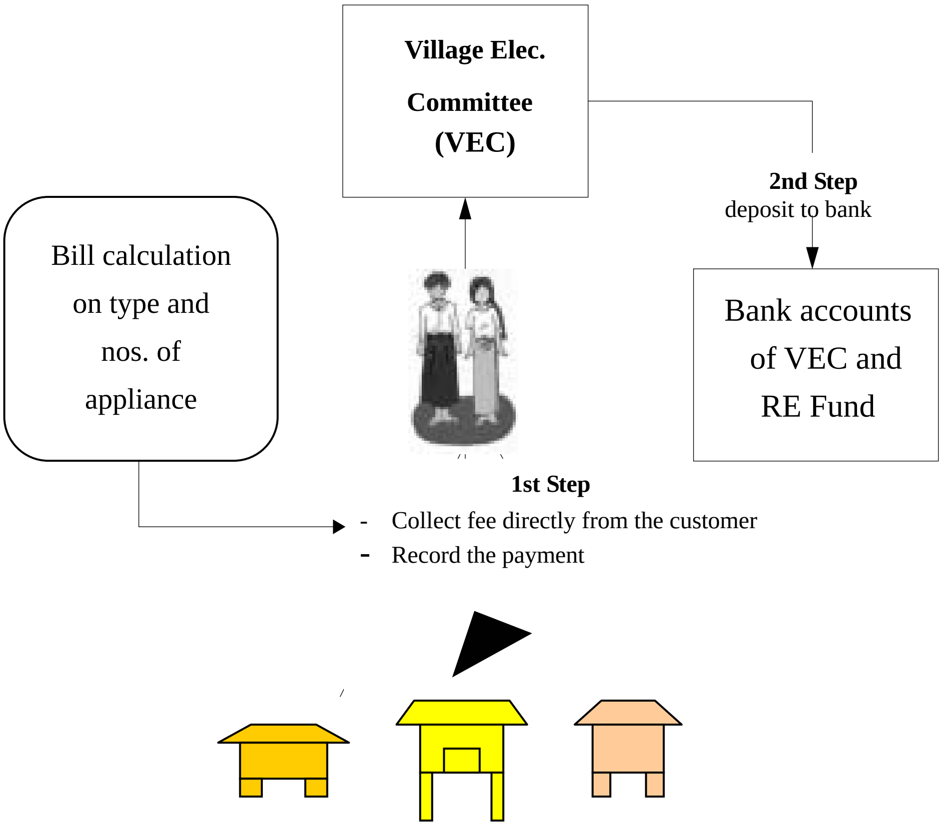
For example, a monthly charge for a lamp is K200 and K400 for other appliances like radio or TV. The monthly charge to a household with three lamps and one radio comes to K1,000, equivalent to US$1.54.

The battery-charging fee should be competitive with other markets so that the charging fee could be a little less than the nearby market rate.

### 4.7.2 Accounting System

Accounting is integrated into billing. As shown in the next figure, the billing, money collection, repayment if implemented with loan, and surplus fund custody may be done as follows:

1) The VEC member in charge of the billing directly visits the customer, collects money, records the payment and issues a receipt at the same time. The charge is calculated with the tariff table set for various types of appliances (lamp, radio, TV and etc).
2) The VEC deposits surplus money to the bank account of VEC. In the case of ***Village Schemes*** financed by the RE Fund, VEC will deposit monthly repayment to the bank account of the RE Fund in accordance with the repayment schedule.
   The battery-charging fee will be paid at BCS and settled with the VEC account after subtracting necessary expenses.




Source: JICA Study Team

**Figure 4.7.1 Billing and Money Collection**

**References**

1) "Biomass gasification", Chanmdrakant TURARE, ARTES Institute, University of Flensburg
2) "Studies on the development of a Rice Husk Gasification and Utilization System" Hironoshin TAKAO, Toshizo BAN, and Kotaro KUBOTA, Technical Report of the Institute of Agricultural Machinery No. 25

# *APPENDIX – A*

# *PROJECT SHEET*

**Project Sheet SH-01: The Inle Lakeshore Rural Electrification Project in Southern Shan**

| | |
|---|---|
| 1. Sector/Sub-sector:<br>Energy/Rural Electrification | 2. Location:<br>Nyaung Shwe, Southern Shan |

3. Implementing Agencies:

Myanma Electric Power Enterprise (MEPE)

4. Objectives:

1. To electrify the villages of Nyaung Shwe Township situated along the shore of Inle Lake and to substantially improve the present supply conditions in those villages having minimum access to electricity (8 W tube-light with small battery);
2. To demonstrate that full scale rural electrification on a 24 hour basis can be realized through development of local hydropower potential;
3. Also, the extra energy available in the rainy season may be fed into the National Main Grid, making the financial viability of the RE Project very high and attractive; and
4. To demonstrate and transfer the know-how of tunneling works, through the provision of tunneling equipment and tunneling professionals.

5. Justification:

1. Nyaung Shwe Township covers 8 Quarters and 35 Village Tracts. It has a large population of about 153,000 in 23,552 households. The households in the villages are 21,690 with population of 140,454 (92% of the total).
2. The household electrification ratio was 52% in the 8 quarters of Nyaung Shwe Township in 2001 but only 0.4% in the 35 village tracts where 92% of the population reside.
3. Assuming 100 W is to be supplied at the initial stage to all the households not electrified yet, the required capacity for power supply will be 2,700 kW including 20% as distribution losses. The demand would be doubled within a few years after the commissioning.
4. There is an idea to electrify cooking in semi-urban households in the region like Kalaw, Aungban, Heho, Shwe Nyaug, and Nyang Shwe through the introduction of strategic power tariffs. This aims to reduce the demand for firewood and charcoal in the semi-urban households which has reportedly caused denudation of the Upper Balu Chaung Basin, particularly on the west bank of Inle Lake contributing to eutrophication of the lake.

6. Project Description:

1. A run-of-river type hydropower plant with an installed capacity of some 8 MW will be constructed on the Negyiya Chaung near Heho.
2. The power generating facilities will include an intake weir, desilting basin, headrace tunnel of about 1,000 m long, head tank, penstock of about 700 m long, power house accommodating two units of turbine generators.
3. The power distribution facilities will consist of a main transformer and switching equipment, 33-66 kV distribution lines alon the shore of Inle Lake, pole-mounted distribution transformers, house-connection wiring, and connection to the 66 kV substation of the Main Grid.

7. Implementation Period:

24 months including test operation

8. Estimated Benefit and Beneficiaries:

| | |
|---|---|
| 9. Estimated Environmental Impacts:<br>No special changes anticipated. | 10. Estimated Costs:<br>US$ |

Heho Falls, West of Inle Lake, Southern Shan State
[1st Field Assignment(Feb.2001), 2nd Field Investigation(May-Jun.2001)]

1. Discharge Measurement at the Intake Site

2. Heho Waterfall

3. Intake Site

4. Penstock Slope from Head Tank

5. Penstock Slope

6. Powerhouse Site

Heho Falls, West of Inle Lake, Southern Shan State
[2nd Field Investigation (May-Jun.2001)]

1. Heho Dam

2. Outflow from Heho Dam

3. Dried River in U/S Basin

4. Gorge of Negya Chaung

5. Inle Lake

6. Fisherman in Inle lake

**Project Sheet SH-02: The Nam Lan Rural Electrification Project in Northern Shan**

| 1. Sector/Sub-sector: Energy/Rural Electrification | 2. Location: Nam Lan, Northern Shan |
|---|---|
| 3. Implementing Agencies: Myanma Electric Power Enterprise (MEPE) | |
| 4. Objectives:<br>1. To electrify the villages of Nam Lan and substantially improve the present supply conditions in the households having power supply of 3 hours a day at very low voltages, or having only an 8 W tube-light with small battery;<br>2. Although the power system will be the property of MEPE, its O&M and management of the electricity business may be entrusted to the Village Electrification Association or Committee, except for major inspection and overhaul of the turbines, generators, etc.;<br>3. The target is to achieve significant financial surplus of the electricity business before the depreciation costs of the Pilot Project, as well as to realize the O&M and management of the business without stationing MEPE staff at the site. These aims are to promote further rural electrification in the other parts of the country by mitigating the financial burden on MEPE and avoiding an increase of MEPE staff for O&M of small RE schemes. | |
| 5. Justification:<br>1. Nam Lan covers 11 Quarters and 5 satellite villages. There are 1,970 households including 204 in villages and the population is 10,036 with the village population being 822. Nam Lan may be called as semi-urbanized village.<br>2. Of the 1,970 households, only 284 were electrified with power supply by MEPE. The electrification ratio was only 16 % in 11 the Quarters and nil in the 5 villages;<br>3. Assuming 100 W is to be supplied at the initial stage to all 1,970 households in Nam Lan, the required capacity for power supply will be 220 kW including 10 % as distribution losses. The demand would increase to 280 kW at an assumed growth rate of 5 %/yr within several years after commissioning;<br>4. There would be day time demand from 18 rice-mills, 6 oil mills for ground nut, 4 mechanical repair shops existing at present; and<br>5. Nam Lan is accessible by 2-3 hour drive on the road from Hsipaw even in the rainy season. The road from Nam Lan to the site requires significant improvements. | |
| 6. Project Description:<br>1. A run-of-river type hydropower plant with an installed capacity of some 300 kW will be constructed on the Ho Sant Chaung, situated 4.5 miles from Nam Lan.<br>2. The power generating facilities will include 3-4 small scale diversion facilities, a desilting basin, a head tank, a penstock, and a power house.<br>3. The power distribution facilities will consist of a main transformer and switching equipment, 11 kV distribution lines, pole-mounted distribution transformers, and house-connection wiring. It will be an isolated power system for the time being but could be connected to the Grid in the future. | |
| 7. Implementation Period: 18 months (two dry seasons) | |
| 8. Estimated Benefit and Beneficiaries: | |
| 9. Estimated Environmental Impacts: No special changes anticipated. | 10. Estimated Costs: US$ |

Nam Lan, South of Hsipaw, Northern Shan State
[1st Field Assignment(Feb.2001), 2nd Field Investigation (May-Jun.2001)]


1. Discharge Measurement in Hosang Chaung


2. Regulating Pond Site


3. Diversion Channel Route


4. Penstock Slope from P/H


5. Powerhouse Site


6. Na Pangkan Chaung

Nam Lan, South of Hsipaw, Northern Shan State
[2nd Field Investigation (May-Jun.2001)]


1. Saw Mill in Nam Lan


2. Myanmar Timber Enterprise near Nam Lan


3. Rice Mill in Nam Lan


4. Oil Mill in Nam Lan


5. Furniture Mill in Nam Lan


6. Un-electrified village in Nam Lan

Nam Lan, South of Hsipaw, Northern Shan State
[3rd Field Investigation (Sep-Oct.2001)]

Kyutaw Chaung

Na Pankan Chaung

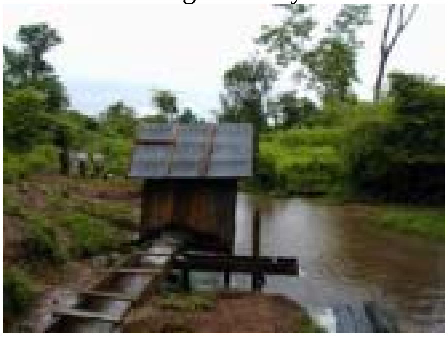
E.P. of Head Pond

Anchor Block #1

Penstock Route

Penstock slope

Hosang Pico Hydro



Kyutaw Pico Hydro (5kW)

**Project Sheet SH-03: The Parhe Rural Electrification Project in Northern Shan State**

| 1. Sector/Sub-sector:<br>Energy/Rural Electrification | 2. Location:<br>Naung Cho in Northern Shan State |
|---|---|
| 3. Implementing Agencies:<br>Myanma Electric Power Enterprise (MEPE) | |
| 4. Objectives:<br>1. To electrify the villages around Parhe Falls in Naung Cho Township.<br>2. To improve the present poor conditions of the local people in the area.<br>3. To develop the local industries such as coffee plantation and agriculture. | |
| 5. Justification:<br>1. There are 9 un-electrified villages with 2,000 households near the site, Banhwe Village being the largest.<br>2. The Parhe Hydropower Project could generate about 340 kW output on a 24-hour basis, even in the dry season, to supply electricity to the surrounding villages. Excess power would be supplied to the National Grid at Pying Oo Lwin by connecting to the existing 11 kV line between Pying Oo Lwin and Hsipaw via Naung Cho.<br>3. There is an existing road up to the site constructed by a New Zealand group for access to a coffee plantation, which is about 7 km branched from the National Road Route #3 and an 11 kV line runs along side the roadway. | |
| 6. Project Description:<br>1. A run-of-river type hydropower plant with an installed capacity of about 340 kW (9.8 x 1.1 m3/sec x 45 m x 0.7)<br>2. The Project consists of the following structures: intake weir with sediment flushing facilities, intake facilities with de-silting basin, open channel waterway, head tank, penstock, powerhouse, outdoor switchyard, and transmission line with 11 kV x 7 km long.<br>3. The intake can be located at the right bank of the Parhe Chaung, and the power waterway leads the water through the right bank to the powerhouse to be constructed at the downstream point of the waterfalls. | |
| 7. Implementation Period:<br>2 years | |
| 8. Estimated Benefit and Beneficiaries:<br>People of 9 villages nearby the site who receive electricity supply from the Parhe Chaung Hydropower Plant | |
| 9. Estimated Environmental Impacts:<br>No special changes anticipated. | 10. Estimated Costs: |

Parhe Chaung, South West of Naungcho, Northern Shan State
[10 Feb. 2001 during 1st Field Investigation]

1. Existing Bridge near Intake Site

2. Intake Site (view from u/s)

3. Regulating Pond Site

4. Parhe Falls

5. Penstock Slope

6. Tailrace (view from P/H)

**Project Sheet SH-04: The Nam Kone Rural Electrification Project in Northern Shan State**

| | |
|---|---|
| 1. Sector/Sub-sector:<br>Energy/Rural Electrification | 2. Location:<br>Manton in Northern Shan State |
| 3. Implementing Agencies:<br>Myanma Electric Power Enterprise (MEPE) | |
| 4. Objectives:<br>1. To electrify the villages in Manton Township in Northern Shan State.<br>2. To improve the present poor conditions of the local people in the area.<br>3. To develop the local industries such as pickle and brick manufacturing. | |
| 5. Justification:<br>1. There are un-electrified villages with population of 1,512 and 197 households in Manton Township.<br>2. The Nam Kone Chaung Hydropower Project could generate about 400 kW output on 12 peak hours operation in the dry season and on 24 hours basis in the rainy season to supply electricity to Manton Township including nearby villages. | |
| 6. Project Description:<br>1. A run-of-river type hydropower plant with an installed capacity of about 400 kW (9.8 x 0.93 m3/sec x 32 m x 0.7 x 2 )<br>2. The Project consists of the following structures: intake, intake facilities with de-silting basin, open channel waterway (750 m long), regulating pond, penstock (74m long), powerhouse, outdoor switchyard, and transmission line with 11 kV x 3 km long. | |
| 7. Implementation Period: | |
| 8. Estimated Benefit and Beneficiaries:<br>People of Manton Township who receive electricity supply from the Nam Kone Chaung Hydropower Plant | |
| 9. Estimated Environmental Impacts:<br>No special changes anticipated. | 10. Estimated Costs: |

**Project Sheet SH-05: The Maing Pying Rural Electrification Project in Eastern Shan State**

| 1. Sector/Sub-sector: | 2. Location: |
| --- | --- |
| Energy/Rural Electrification | Maing Pying in Eastern Shan State |

3. Implementing Agencies:

Myanma Electric Power Enterprise (MEPE)

4. Objectives:

1. To electrify the villages of Maing Pying township including surrounding villages.
2. To improve the present poor conditions of the local people in the remote area.

5. Justification:

1. Maing Pying is an isolated township, 6 hours drive from Kyaing Ton in Eastern Shan State, with a population of 58,740 in 8,772 households. In the town (population of 5,645, in 713 households) and surrounding 343 villages (balance of population) the electricity has been in such short supply that it has only be supplied to 200 households from 18:00 to 21:00 every 2 days by diesel generators of 120 kW.
2. The Nam Uon Chaung Hydropower Project can generate about 530-800 kW output to supply electricity to Maing Pying Township including the surrounding villages.
3. There is a possibility to develop bio-gas power by the use of rice husk available in this area to supplement the hydropower.
4. Local authorities and people of Maing Pying strongly desire the electricity to improve the living standard, education and welfare amongst the lowest class since there are no alternative power sources other than the Project.

6. Project Description:

The Project is located at Nam Uon Chaung 4km northwest of Maing Pying in Eastern Shan State.

1. A run-of-river type hydropower plant with an installed capacity of about 530-800 kW (9.8 x (0.6-0.9) $m^3$/sec x 130 m x 0.7)
2. The Project consists of the following structures: intake weir with boulder flushing facilities, intake facilities with de-silting basin, open channel waterway, head tank, penstock, powerhouse, out door switchyard with main transformers, and transmission line with 11 kV x 4 km long.
3. The intake can be located at the left bank of the Nam Uon Chaung, and the power waterway leads the water along the mountain slope in the left bank via head tank and penstock to the powerhouse to be constructed 2 km from Wan Kawn village near Nam Ping River.
4. An existing road is available from Maing Pying along the Nam Ping River. A river crossing facility such as a causeway at Nam Ping River and access road to the intake via the powerhouse is required to be constructed.

7. Implementation Period:

2 years

8. Estimated Benefit and Beneficiaries:

People of Maing Pying Township who receive electricity supply from the Nam Uon Chaung Hydroelectric Power Plant

| 9. Estimated Environmental Impacts: | 10. Estimated Costs: |
| --- | --- |
| No special changes anticipated. | US$ 4,000 x 800 kW = US$ 3,200,000 |

Nam Uon Chaung, Maing Pying, Eastern Shan State
[30 May 2001 during 2nd Field Investigation]


1. Intake Site : View from D/S


2. Existing Irrigation Intake


3. Waterway Route along Existing Irrigation Channel


4. Waterway Route along Mountain Slope


5. Penstock Slope


6. Powerhouse Site

**Project Sheet SH-06: The Gangaw Rural Electrification Project in Magway Division**

<table>
<tr><td>1. Sector/Sub-sector:<br>Energy/Rural Electrification</td><td>2. Location:<br>Gangaw in Northern Magway Division</td></tr>
<tr><td colspan="2">3. Implementing Agencies:<br>Myanma Electric Power Enterprise (MEPE)</td></tr>
<tr><td colspan="2">4. Objectives:<br>1. To electrify the villages of Gangaw Township including surrounding villages.<br>2. To improve the present poor conditions of the local people in the remote area.<br>3. To develop the local industries with a high potential.</td></tr>
<tr><td colspan="2">5. Justification:<br>1. Gangaw is an isolated township, 11 hours drive from Mandalay, 9 hours from Monywa, with a population of 23,976 and 4,289 households in the town and surrounding 4 villages. Electricity has only been supplied from 18:00 to 21:00 every 2 days by diesel generators of 424 kW to 660 households.<br>2. The Zhaw Chaung Hydropower Project can generate about 1,200 kW output to supply electricity to Gangaw Township including some villages.<br>3. There exists a high potential for local industries requiring power supply for development, such as sawmill, furniture, weaving, oil manufacturing, municipal water supply, and irrigation water supply for paddy and bean fields.<br>4. A hydroelectric committee has been established for promoting Zahaw Chaung Hydropower Project, since there are no alternative power sources other than the Project to improve the living standard in the lowest class and to develop the local industries.</td></tr>
<tr><td colspan="2">6. Project Description:<br>The Project is located at Zahaw Chaung 10 km upstream from the confluence with the Myittha River in Northern Magway Division.<br>1. A run-of-river type hydropower plant with an installed capacity of about 1,200 kW (9.8 x 12m3/sec x 15m x 0.7 )<br>2. 24 hours operation in rainy season from June to October with 1,200 kW, and 400 kW~600 kW peak operation in the dry season, although discharge measurements throughout the year are required finalize details of the scheme.<br>3. The Project consists of the following structures: intake weir with sediment flushing facilities, intake facilities with de-silting basin, open channel waterway, head tank, penstock, powerhouse, outdoor switchyard with main transformers, and transmission line with 11 kV x 10km long.<br>4. The intake can be located at the left bank of the Zahaw Chaung, and the power waterway leads the water through the left bank to the powerhouse to be constructed at the downstream section of the waterfalls of Zahaw Chaung.<br>5. An existing road is available from Gangaw to the site for access.</td></tr>
<tr><td colspan="2">7. Implementation Period:<br>2 ~ 3 years</td></tr>
<tr><td colspan="2">8. Estimated Benefit and Beneficiaries:<br>People of Gangaw Township who receive electricity supply from the Zahaw Hydroelectric Power Plant</td></tr>
<tr><td>9. Estimated Environmental Impacts:<br>No special changes anticipated.</td><td>10. Estimated Costs:<br>US$ 4,000 x 1,200 kW = US$ 4,800,000</td></tr>
</table>

Zahaw Chaung, Gangaw, Northern Magway Division
[7-8 Jun. 2001 during 2nd Field Assignment]


1. Intake Site : View from D/S


2. Water Fall of Zahaw Chaung


3. Zahaw Chaung


4. Penstock at Left Bank Slope


5. Powerhouse Site : View from D/S


6. Saw Mill in Gangaw

## Project Sheet SH-07: The Dawai Rural Electrification Project in Tanin Tharyi State

| | |
|---|---|
| 1. Sector/Sub-sector:<br>Energy/Rural Electrification | 2. Location:<br>Dawai Township in Tanin Tharyi State |

3. Implementing Agencies:

Myanma Electric Power Enterprise (MEPE)

4. Objectives:

1. To electrify Dawai Township including villages.
2. To supply irrigation water to farm land of 1,300 ha in Dawai Township.
3. To supply drinking water to Dawai Township.

5. Justification:

1. Anyapya power plant will supply electricity to Dawi Township, which is facing severe electricity shortage for domestic, industrial, agricultural and public demands.
2. Anyapya dam will supply irrigation water to the paddy fields of 1,300 ha to enable a second rice crop during the dry season.
3. Anyapya dam will supply drinking water to Dawai Township

6. Project Description:

1. A dam type hydropower plant with an installed capacity of about 9,300 kW :

| | |
|---|---|
| Catchment area | 111km$^2$ |
| Annual mean discharge | 18.93m$^3$/sec |
| Dam | Rockfill dam of center core type with 48m high and 450,000m$^3$ in volume |
| Reservoir | 270 x 10$^6$ m$^3$ |
| Headrace tunnel | 6.0 m x 197m + 3.2 m x 41m |
| Penstock | 3.2 m x 31m |
| Head (max) | 41.5m |
| Discharge (max) | 32.96m$^3$/sec |
| Turbine | Kaplan type, 9.3 MW (3.1 MW x 3 units) |
| Transformer | 12 MVA (4 MVA x 3 units), 6.3 kV/33 kV |
| Transmission line | 33 kV x 14.5 km |

7. Implementation Period:

8. Estimated Benefit and Beneficiaries:

People in Dawai Township

| | |
|---|---|
| 9. Estimated Environmental Impacts:<br>No special changes anticipated. | 10. Estimated Costs: |

**Project Sheet BM-01: The Model Villages for Rural Electrification with Rice Husk Gas Engine and Solar BCS**

| 1. Sector/Sub-sector: | 2. Location: |
|---|---|
| Energy/Rural Electrification | Than Lyin and Hmaw bi Townships, Yangon Division |

3. Implementing Agencies:

VEC of each village with NGO

4. Objectives:

1. To implement the Model Villages for Rural Electrification with Rice Husk Gas Engine and Solar BCS that are to be managed by the Village Electrification Committee (VEC);
2. To test the proposed implementation of Village Electrification by VEC on a self reliance basis with support from an NGO and RE Fund.
3. To test and monitor the performance, O&M, and management of the Project by the VEC in order to identify ways to best-adapt the model to the paddy cultivating villages in Myanmar.

5. Justification:

1. The Rice Husk Gas Engine has been installed at more than 100 locations in Myanmar to prove its technologyicaly soundness. It is appreciated that the Rice Husk Gas Engine has prospects to become Star in the rural electrification of the paddy-cultivating villages;
2. Its fuel is rice husk or sawdust waste from rice-mills or sawmills. These are renewable, clean, indigenous to the country, and available at almost at no cost;
3. The power output could range from 20 kW to over 100 kW which corresponds to a village scale of 200 to 1,000 households if 100 W is to be supplied to each household. The output is good enough to cover most of the village sizes in Myanmar.
4. The power has been used also for operating rice-mills, ice-plants, cooking oil processor, drying vermicelli, etc.
5. Solar and/or wind powered BCS can electrify those small villages located in remote and poorly accessible areas in the shortest time among the alternative energy sources;
6. Solar power is maintenance-free while wind power is available even in the rainy season;
7. If the initial costs are supported and borne by external resources, those villages can enjoy the minimum lighting for the expense of buying battery and lights.

6. Project Description:

While the Rice Husk Gas Engine will electrify those households located in the central part of the village within 1,000 m cable distance from the engine, the households in the peripheral zones around the village may be electrified by the line-fed BCS and small satellite villages scattered further outside by the solar powered BCS.

1. To install one set of rice husk gas engines to each village, with 400/230 V distribution lines to each consumer;
2. To install one solar BCS with one 500 W; and to execute improvement tests (introduction of new battery charging controller); and
3. To monitor the implementation, test operation, and management of the Model Villages by VEC for one year and to achieve best adaptation.

7. Implementation Period:

18 months including test operation

8. Estimated Benefit and Beneficiaries:

People of Myanmar who receive electricity supply from the Model Villages in the short-term, and the people living in the non-electrified rural area in the medium to long-term.

| 9. Estimated Environmental Impacts: | 10. Estimated Costs: |
|---|---|
| No special changes anticipated. | wtihin US$ 80,000 |

Kayin Seik, Yangon Division
[Field Investigation(Sep.2001)]

1.Meeting at Monastery with VEC

2. Cooking using Rice Husk

3. Video House in Kayin Seik

4. Rice Mill in Kayin Seik

5. P Road in Banbwe Kone

6. Saw Mill in Banbwe Kone

**Project Sheet BM-02: The Project for Promotion of Rural Electrification with Rice Husk Gas Engine in Ayeyawady Division**

1. Sector/Sub-sector:
Energy/Rural Electrification

2. Location:
Ayeyawady Division

3. Implementing Agencies:

Village Electrification Association (VEC) to be established in each village

4. Objectives:

1. To improve household electrification ratio by 30 % in 5 years in Ayeyawady Division through strategic promotion of rice husk gas engine, as a model of Rural Electrification in paddy cultivating regions in Myanmar.

5. Justification:

1. Ayeyawady Division has 26 Townships, population of 6.44 million in about 1 million households, and paddy production of about 5.9 million ton;
2. If only 20 % of the rice husks in the Division is used for power generation with husk gas engine, it will generate electric energy of 107 GWh which can supply electricity to 300,000 households at a rate of 200 W for 5 hours a day throughout the year. It is not a dream but within a reach in view of technology, fuel resources, and fund requirement;
3. Since there is only one cooperative that can manufacture the rice husk gas engine and a great demand on the rural electrification with gas engine is forecast, there will be issues:
   - Manufacturing capacity of the rice husk gas engine systems may be limited;
   - Experienced staff for installation, commissioning test, and initial training of O&M personnel may be limited;
   - Post-installation services for the systems already installed will be important.

6. Project Description:

1. To establish Husk Division in the Rural Electrification Center which will provide information and technical support for introducing rice husk gas engine;
2. To establish Rural Electrification Fund which will provide no-interest loans for up to one year to help arrange the initial capital costs for procurement;
3. The objective of household electrification ratio of 30 % corresponds to new electrification of about 300,000 households. The beneficiary will be about 1.8 million. Assuming one power system can supply 500 households on an average, 600 power supply systems will be needed in 5 years, that is, new installation of 120 systems a year. (52 systems will be installed in 2001);
4. The RE Fund would need annual lending in an order of US$ 1.5 million (= US$12,000 x 120 systems/yr). The financial costs of the Fund would be about US$0.15 million a year as 10% of the revolving fund.
5. In addition to the Fund above, the administration costs of the Implementing Agency and costs for information and technical supports by Husk Division of REC will be needed.

7. Implementation Period:
Five years

8. Estimated Benefit and Beneficiaries:

1.8 million people in Ayeyawady Division

9. Estimated Environmental Impacts:

No special changes anticipated.

10. Estimated Costs:

Revolving fund at US$ 1.5 million plus running fund at US$ 0.15 million plus running costs of Husk Division of REC at US$ 0.2 million

Younethalin, Ayeyawady Division
[1st Field Assignment(Feb.2001), 2nd Field Invewstigation(May-Jun.2001)]


1.Power House


2. Generation System Beside Rice Mill


3. Generator


4. Input Rice Husk to Gasifier


5. Rice Husk Storage


6. Factory of Husk Generation System

**Project Sheet BM-03: The Project for Promotion of Rural Electrification with Rice Husk Gas Engine and Solar-Wind BCS in Kachin State**

| 1. Sector/Sub-sector:<br>Energy/Rural Electrification | 2. Location:<br>Northern Kachin State |
|---|---|

3. Implementing Agencies:

Village Electrification Association (VEC) to be established in each village

4. Objectives:

1. To electrify the villages in Putao, Machan Baw, Chi-Pwi, Hsaw-Olaw, Kyaung Ianfu, Naung Monn, and Tanai Townships with rice husk gas engines and solar BCS.

5. Justification:

1. The villages in Upper Kachin have poor access even in the dry season. It is a 2-day drive to reach Putao from Myitkyina in the dry season. Diesel oil is air-transported before the rainy season. The number of vehicles/trucks in the District Center Putao was less than 20 even in 2001.
2. There is one mini-hydro station in Putao, supplying only the central part of the Putao Township. There is one rice husk gas engine to power the rice mill in Putao.
3. The other source of electricity is small diesel generators and batteries.
4. It is reported that batteries are rarely transported to the Putao area since they cannot be air-cargoed due to safety restrictions. These should be road-transported during the dry season.
5. The villages in the Upper Kachin would remain unelectrified even after tens of years unless strategic support is given to achieve electrification with a rice husk gas engine and solar BCS, whichever best suits the village conditions.
6. The only resources in the Region may be human resources. In order to further develop the human resources, it is essential to provide modern education including the latest information from the world. Electricity supply to the schools and clinics are basic needs of the Region.

6. Project Description:

Two villages each of the seven townships will be electrified using rice husk gas engine where enough husk is available and the village scale is large, and using solar BCS where not enough husk is available or the village scale is too small.

In view of the scattered villages in the remote and poorly accessible areas, the Project is planned for implementation in 4 phases:

- Phase 1: Putao and Machan Baw Townships
- Phase 2: Chi-Pwi and Hsaw-Plaw Townships
- Phase 3: Kyaung Ianfu and Naung Monn Townships
- Phase 4: Tanai Township

The rural electrification systems will be managed by a Village Electrification Committee that is yet to be established.

7. Implementation Period:

18 months including test operation

8. Estimated Benefit and Beneficiaries:

| 9. Estimated Environmental Impacts:<br>No special changes anticipated. | 10. Estimated Costs:<br>US$ 80,000 per phase |
|---|---|

**Project Sheet BM-04: The Pilot Project for Diesel Substitute of MEPE Power Plants for Rural Electrification**

| | |
|---|---|
| 1. Sector/Sub-sector:<br>Energy/Rural Electrification | 2. Location:<br>to be selected from MEPE Township Office |
| 3. Implementing Agencies:<br>MEPE | |
| 4. Objectives:<br>1. To test and prove the performance of the proposed substitution of diesel oil of the MEPE diesel power plants with biomass gas;<br>2. To test and prove the synchronized operation of multiple gas engine generators.<br>3. To test and prove the performance using the 11 kV distribution. | |
| 5. Justification:<br>1. MEPE operates 456 sets of diesel generators in the local Township Offices, with an additional 69 units on standby. The total capacity is 65 MW.<br>2. Because of limited budget for diesel oil, these diesel generators are operated only 3 hours a day.<br>3. A total generation of 44 GWh by diesel generators in 2000 needed fuel costs of about US$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 US$45 million (K22.4 billion) in 2000. A 3.1 % of the gross revenue was spent for purchasing diesel for RE. If it is valued at market price K600/gallon, the diesel cost would amount to US$5.3 million (K2.6 billion) or 12 % of the total budget of MEPE. Saving and substitute of fuel oil are of the prime issue of not only from financial aspects of MEPE but also from the Nation’s economy. | |
| 6. Project Description:<br>1. To install one set of gasifier and engine;<br>2. To implement a few Model Projects;<br>3. To execute performance tests for 3 years; | |
| 7. Implementation Period:<br>4-5 years | |
| 8. Estimated Benefit and Beneficiaries:<br>MEPE | |
| 9. Estimated Environmental Impacts:<br>No special changes anticipated. | 10. Estimated Costs: |

**Project Sheet SW-01: The Project for Promotion of Rural Electrification with Solar-Wind BCS in Kachin State**

| 1. Sector/Sub-sector: Energy/Rural Electrification | 2. Location: Kaungmu-lonvillage, Machan Baw Township, Putao District, Kachin State |
|---|---|

3. Implementing Agencies:

Kaungmu-lon Village Electrification Committee (VEC) has to be established under VPDC together with REAM official participation by sharing specific responsibilities in the implementation process.

REAM will co-operate in various implementation phases of the project to do necessary technical supports in project preparation, installation, operation and training, and also monitoring the data logging system of the project.

4. Objectives:

1. To electrify the villages in Putao District, Machan Baw Township, Kaungmu-long village with PV and Wind BCS.

5. Justification:

1. This village in Upper Kachin is poorly accessible even in the dry season. It needs 2-days driving to reach Putao from Myitkyina in the dry season. Diesel oil is air-transported before the rainy season. The number of vehicles/trucks in the District Center Putao was less than 20 even in 2001.
2. There is no regular power supplying system to that village. There is one diesel generator set (7 kVA) which is provided by the government for a pagoda construction site. Fuel transportation, even from Putao to the village is very difficult. There is no regular transportation and the cost of car hire is very expensive. The other source of electricity is small batteries charged from the nearest village of Tran-dan (two miles foot by road) where one small engine (3 kVA ) is provided to facilitate crop grinding.
3. It is reported that availability of batteries, even at Putao, is low due to difficulty of transportation from the main regional center (Myitkyina). Batteries cannot be transported by air due to safety restrictions and have to be road-transported during the dry season only.
4. The villages in the Upper Kachin would remain un-electrified even after tens of years unless strategic support is given to achieve electrification with renewable energy sources such as solar and/or wind powered BCS, whichever best suits the village conditions.
5. The only resources in the Region may be human resources. In order to further develop the human resources, it is essential to provide the modern education including latest information from the world. Electricity supply to the schools and clinics are basic needs of the Region.
6. Kaungmu-lon village is a government rehabilitation model village which was established in late 2000, by organizing the surrounding moving families who practicing slash & burn farming and seriously degrading the forest areas. The government supports the model village along with houses and farm-land for each family. The families that have started establishing here are, Kachin, Lee-su, Shan and La-wan.
7. Recently, villagers have Village Electrification Committee (VEC), to operate and manage the available power source.
8. The village area has enough space and buildings to establish and install a solar/wind hybrid system. The VEC agree to contribute the necessary buildings and other raw construction materials as much as possible, together with labor force from their side.

9. There are another three villages ( Ngwar-zar, Salun-dun and Kan-cho) near by – with 80, 40 and 60 households each within a 1-mile radius. The primary school children from those villages have no regular power source for nighttime lighting.
10. Electrical energy is urgently required in the rehabilitation area to organize and rise the people's awareness of the importance of protecting their unique environment with rich biodiversity and to enable their development by taking a key role in providing themselves with a renewable energy source.

6. Project Description:

Kaungmu-lon village will be electrified using PV and wind powered hybrid renewable energy systems for which solar radiation and seasonal wind sources are available and by using solar BCS where battery-powered electrification practices are familiar to the villagers.

In view of the urgent need to fulfill basic energy needs and for long term project scheme improvement and propagation in surrounding areas, it is necessary to immediately install a wind and solar power supply system together with a system for wind and solar power resources and energy output .

Particular specifications and performance descriptions for PV and Wind generators are attached in a separate sheet.

Detailed facts and figures for cost estimation and load particulars are also attached in separate sheet.

The project is planned for implementation in the following phases:

- Phase 1: Site preparation and planning for material handling, transportation and installation processes between Local authorities, VEC and REAM through the guideline of JICA Renewable Energy Study Team for Myanmar.
- Phase 2: System establishment and performance testing.
- Phase 3: education and training on system operation, administration, maintenance and data logging system monitoring procedures between VEC and REAM.

The rural electrification systems will be managed by VEC to be reformed and established to meet with the official requirements for activities under the VPDC.

REAM will carry out the necessary technical support for system installation, training & education and further monitoring for system establishment and for one year of system operation (based on JICA/RE Team arrangement).

VEC has to do all the necessary data recording along with the set procedures, and REAM will compile the necessary documentation for JICA and other necessary official reports required.

7. Implementation Period:

18 months including test operation

8. Estimated Benefit and Beneficiaries:

Three villages of 382 households and population of 2282 will beneft from the Project.

Local people around the area will have an improved awareness of RET application and environmental situation of RET through practical implementation of the project.

Data of the project will support the propagation and development of such kinds of projects in surrounding areas.

The achievement of the project will form an incentive for local shifting-cultivators to settle and farm in one place and systematically upgrade their living standard and knowledge. This will protect and improve the forest and soil environment of the area in a sustainable measure.

| 9. Estimated Environmental Impacts: | 10. Estimated Costs: |
|---|---|
| No special changes anticipated. | US$ |

**Project Sheet SH-02: The Project for Promotion of Rural Electrification with Wind BCS in Magwe Division**

| 1. Sector/Sub-sector: Energy/Rural Electrification | 2. Location: Ahlae-thaung village, Yasakyo Township, Pakokekku District, Magwe Division |
|---|---|

3. Implementing Agencies:

Ahlae-thaung Village Electrification Committee (VEC) has to be established under VPDC together with REAM official participation by sharing specific responsibilities in implementation process.

REAM will co-operate in respective implementation phases of the project to do necessary technical support in project preparation, installation, operation and training, and also monitoring the data logging system of the project.

4. Objectives:

1. To electrify the villages with Wind BCS.

5. Justification:

1. This village is situated on an island in Ayeyarwady - near the junction with the Chindwin river and windy without wind-break surrounding the island.
2. There is no regular power supplying system to the village. The most common source of electricity is small batteries. Transportation of batteries is difficult, because of the route to the nearest charging station is only accessible by small boat and foot path-way.
3. It is reported that there is no proper battery repair facilities and most old batteries used by the villagers are partially damaged due to hard transportation .
4. For villages in the middle of a big river it is always hard to transport fuel and also grid line extension. Renewable energy sources like PV and/or wind power systems are best choice to suit the village conditions.
5. Villagers are interested to form a Village Electrification Committee (VEC), to operate and manage the available power source.
6. The village area has enough space and buildings to establish and install a PV/wind hybrid system.
7. Electrical energy is urgently required in this kind of isolated area to promote the living standard of the people.

6. Project Description:

Ahlae-thaund village will be electrified using wind powered renewable energy system because a better wind source is available than at inland areas.

Battery powered electrification is already familiar to the villagers, and the BCS will be used not only for the village, but also the surrounding villages.

This power supply system and systems for logging power output performance and available wind power have to be installed.

The particular specifications and performance descriptions for PV and wind generators are attached in separate sheet.

Detailed facts and figures for cost estimation and load particulars are also attached in separate sheet.

The Project is planned for implementation in the following phases:

- Phase 1: Site preparation and planning for material handling, transportation and installation processes between Local authorities, VEC and REAM through the guide line of JICA Renewable Energy Study Team for Myanmar.

- Phase 2: System establishment and performance testing by VEC and REAM.
- Phase 3: Education and training on system operation, administration, maintenance and data logging system monitoring procedures between VEC and REAM.
- Phase 4: One year monitoring process of Wind Resources and System Performance data collection and power generating System Maintenance task by REAM

VEC has to do all necessary daily data recording along with the procedure and Ream will compile and make necessary systematic documentation for JICA and other official reports required.

7. Implementation Period:

18 months including test operation

8. Estimated Benefit and Beneficiaries:

The villages of Ahlae-thaung with 637 households and population of 3725 will become beneficiaries.

Local people around the area (altogether 9 villages on the same island) will be improved in awareness of RET application and environmental situation of RET through existence of the project on their island.

Data of the project will effectively support propagation and development of projects in surrounding areas

| 9. Estimated Environmental Impacts: | 10. Estimated Costs: |
|---|---|
| No special changes anticipated. | US$ |

## Project Sheet RH-01: The Rehabilitation of Small Hydropower Stations in Myanmar

| 1. Sector/Sub-sector: Energy/Rural Electrification | 2. Location: Whole Myanmar |
|---|---|

3. Implementing Agencies:

Myanma Electric Power Enterprise (MEPE)

4. Objectives:

1. To rehabilitate existing small and mini-hydropower plants in order to fully utilize the hydropower potential and improve the present supply conditions through checking, rehabilitation, and upgrading of intakes, de-sanding facilities, and waterway structures as well as generating equipment.

5. Justification:

8. The existing hydropower plants constructed in mountainous areas have been contributing to the rural electrification in Myanmar.
9. The rehabilitation of such existing plants will increase the station output significantly, since many facilities including hydro-mechanical equipment and controls have been damaged or deteriorated since commissioning.
10. It appears that the issues related to the existing hydropower plants may be attributed mainly to the severe conditions of sediment transport in the rivers and the durability of generating equipment and controllers in particular.
11. The review of design and operation of the civil structures in relation to sediment transport will contribute to utilization of hydropower potential to the possible maximum possible extent.
12. The rehabilitation of existing hydropower plants will contribute not only to the rural electrification but also to saving the fuel consumption of diesel generators, that is, reducing the emission of carbon dioxide.

6. Project Description:

MEPE has constructed 39 small and mini-hydropower plants with the total capacity of 40 MW, and 4 power plants are being constructed at present. However, most of them have some probllems, and many units are not available for operation or are operated at a very low efficiency.

1. To rehabilitate the existing hydropower plants in 4 phases according to the magnitude of damages/troubles and urgency for rehabilitation:

   Phase 1: 7 plants of Priority A including Zawgyi I with top priority given to those in Kachine and Chin States followed by Shan State;

   Phase 2: remaining 7 plants of Priority A;

   Phase 3: 9 plants of Priority B; and

   Phase 4: 8 plants with Priority C.

7. Implementation Period:

6 months for rehabilitation of one plant, and about 2 years for each phase (2 dry seasons).

8. Estimated Benefit and Beneficiaries:

Local people who receive electricity supply from the existing hydropower plants

| 9. Estimated Environmental Impacts: No special changes anticipated. | 10. Estimated Costs: |
|---|---|


Nam Hkam Hka (Kachin) Mar. 2001


Nam Hkam Hka (Kachin) Mar. 2001


Nam Lat (Eastern Shan) May. 2001


Nam Lat (Eastern Shan) May. 2001


Kyaukme (Northern Shan) Feb. 2001


Kyaukme (Northern Shan) Feb. 2001


KyangHkrang Hka (Kachin) Mar. 2001


Putao (Kachin) Mar. 2001

**List of Small and Mini-hydro Power Stations Existing and Under Construction in Myanmar (<10,000 kW) (1/3)**

| No. | State/Division | Plant Name | Commissioned in | C. Area | $P_i$ | | $Q_d$ | $H_g$ | Location | Priority (A to C) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $km^2$ | kW | Unit | $m^3/s$ | m | | | |
| 1 | Kachin State | Putao (Nam Htun) | March 1987 | 134 | 160 | 100+60 | 4.8 | 7.3 | 7 miles from Putao | A | Inspected on 12/3/2001. Hyd. controller needs rehabilitation. The 100 kW machine was procured for the other site and is over-sized to the site head. It could be shifted for full output. |
| 2 | Kachin State | Kampaiti | commissioned | - | 150 | - | - | 28.1 | 0.5 miles from North of Kampaiti | | not known. |
| 3 | Kachin State | Panwa | | - | 160 | - | 0.5 | 36.3 | 1.5 miles North of Panwa | | not known. |
| 4 | Kachin State | Hopin (Glaing Chaung) | Sept. 1991 | 23 | 1,260 | 630 x 2 | 0.8 | 190.5 | 8 miles northeast of Hopin | C | 1st YMEC project in Myanmar. Installed capacity may be increased in view of hydrology. Waterway & penstock design be reviewed. |
| 5 | Kachin State | Chinghkrang Hka | April 1993 | 61 | 2,520 | 630 x 4 | 2.3 | 164.0 | 21 miles from Myitkyina | C | Inspected on 9/3/2001. Chinese machines. Design flood 2,645 cusec. |
| 6 | Kachin State | Namhkam Hka | Sept. 1996 | 36 | 5,000 | 1,250 x 4 | 5.4 | 128.0 | 14 miles east of Magaung | A for governor B for others | Inspected on 10/3/2001. 3 governors out of order. Waterway may be improved and 3 tributaries could be tapped. Design flood 1,500 cusec. |
| 7 | Kachin State | Tumpang Chaung | under const. | 621 | 6,000 | | - | 45.7 | 24 miles northeast of Waingmaw | | |
| 8 | Kachin State | Nan Dabak | under const., planned in 2002 | 134 | 24,000 | 8,000 x 3 | 38.2 | 75.3 | 17 miles S.E. of Maingmaw. | | under construction on IPP basis. Design flood 49,045 cusec. |
| 9 | Kayah State | Hpa Saung (Hwe Kabu Chaung) | Jan. 1988 | 12 | 108 | 54 x 2 | - | 58.5 | Hpa Saung, to the east of Loikaw. | B | Local machines, probably out of order, need rehabilitation. Good location for rehabilitation. Waterway also may need rehabili. |
| 10 | Kayin State | Papun (Lekapaw Chaung) | March 1987 | 3 | 37 | 2 units | - | 24.4 | 1.5 miles from Papun | B | Installed capacity may be increased by more efficient machines. It may not be operable in the dry season. A convoy required to reach the site. |
| 11 | Chin State | Dhobi Chaung | 1975 | - | 60 | | - | - | 2 miles from Falam | | First hydropower in Chin State. No longer exists. |
| 12 | Chin State | Zalui | Feb. 1984 | 24 | 400 | 200 x 2 | - | 148.7 | 4 miles from Tiddim | B | VoestAlpine, Germany. Diversion of water from nearby stream, Haicin Chaung, possible. |
| 13 | Chin State | Daung Va | Sept. 1984 | 64 | 400 | 200 x 2 | - | 79.2 | 8 miles from Haka | B | VoestAlpine, Germany. One machine out of order. |
| 14 | Chin State | Paletwa | Aug. 1988 | 3 | 50 | 25 x 2 | - | 42.7 | 0.5 miles from Paletwo | C | Not in operation anymore. Local authority has interest to reconstruct the plant. |
| 15 | Chin State | Matupi (Namlaung Chaung) | May 1992 | 41 | 200 | 100 x 2 | - | 43.6 | 8 miles east of Matupi | A | Local cross-flow machines. Needs new machines. |
| 16 | Chin State | Laiva | April 1994 | 8 | 600 | 300 x 2 | 0.5 | 193.9 | 110 miles southeast of Falam | B | Chinese machines. Initially Laiva multi-purpose dam with priority for irrigation by ID. No irrigation now and all the water can be used for power --> Hydrology to be restudied. |
| 17 | Chin State | Tui Saung Chaung | July 1997 | 52 | 200 | 100 x 2 | 0.9 | 45.7 | 2 miles northeast of Tonzang | A | Locally made cross-flow turbines. Upgrading possible by new machines. |

## List of Small and Mini-hydro Power Stations Existing and Under Construction in Myanmar (<10,000 kW) (2/3)

| No. | State/Division | Plant Name | Commissioned in | C. Area | $P_i$ | | $Q_d$ | $H_g$ | Location | Priority (A to C) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $km^2$ | kW | Unit | $m^3/s$ | m | | | |
| 18 | Chin State | Che Chaung (Mindat) | Sept. 1997 | 292 | 400 | 100 x 4 (only 2 installed) | 2.5 | 28.0 | 7.5 miles southwest of Mindat | A | Water abundant. Upgrading possible. It needs new machines. |
| 19 | Chin State | Mgalsip Va | Dec. 1986 | 116 | 1,000 | 500 x 2 | - | 117.0 | 12 miles from Falam | A | VoestAlpine. Needs new machines. Others all right. |
| 20 | Sagaing Div. | Lahe (Hwe Hngwin Chaung) | Feb. 1997 | 7 | 50 | 50 x 1 | 0.1 | 59.4 | 1.5 miles southeast of Lahe | A | Local machines. Rehabilitation will be greatly beneficial. |
| 21 | Sagaing Div. | Zi Chaung | July 1996 | 297 | 1,260 | 630 x 2 | 4.0 | 41.0 | 12 miles from Kalemyo | A | Chinese machines. Intake improvement may be required. |
| 22 | Tanintharyi Div | Kattalu Chaung | July 1991 | 18 | 150 | 50 x 3 | - | 52.4 | Kyunsu Township Katan Island | C | Civil structures may remain there but no longer in operation. |
| 23 | Tanintharyi Div | Mali Kyun | July 1992 | 2 | 192 | 64 x 3 | - | 107.0 | Mali Kyun | | Built with local partners. Working all right. Pondage improvement may be required for its leakage. Use for port authority. |
| 24 | Mandalay Div. | Wet Wun | 1933 | 189 | 450 | 225 x 2 | - | 212.8 | 13 miles from Maymyo | A | Very oldd since 1933. Waterway (wooden flume) & machine improvement may increase output. |
| 25 | Mandalay Div. | Mogok | Sept. 1989 | 68 | 4,000 | 2,000 x 2 | - | 120.4 | Mogok Township | **AA** | VoestAlpine. Very high siliting problem due to mining operation upstream. Turbine repaired every 2-3 months. |
| 26 | Mon State | Zingyaik | Oct. 1984 | 3 | 198 | 64 x 3 and 6 x 1 | 0.3 | 109.3 | 6 miles northeast of Paung, on the way to Mawlamyine | A | Very low flow during the dry season. May be possiblee to have another regulating pond upstream. Design flood 3,000 cusec. |
| 27 | Shan State | Namhsan | 1936 (existing) | 17 | 30 | | 0.1 | 27.4 | 1.5 miles from Namhsan | | not known. |
| 28 | Shan State | Muse (Namkhun Chaung) | April 1988 | 26 | 192 | | 0.1 | 47.1 | 4 miles east of Muse | | Renovated with new Chinese machines, needs confirmation. |
| 29 | Shan State | NamKham (Nammahla Chaung) | March 1988 | 29 | 300 | | 0.1 | 42.7 | 6 miles south of Namkham | | Renovated with new Chinese machines, needs confirmation. |
| 30 | Shan State | Kunhing (Namsham Chaung) | Sept. 1991 | 67 | 150 | Turbine 75 x 3 Generator 50 x 3 | - | 25.9 | 2 miles east of Kunhing | A | Chinese machines. Needs rehabilitation very much. |
| 31 | Shan State | Kyaington-2 (Nam Lat Chaung) | Nov. 1991 | 109 | 480 | 160 x 3 | 1.7 | 39.9 | 8 miles southeast of Kyaington | A | Chinese machines. 2 units out of order. Needs rehabilitation very much. Design flood 6,360 cusec. |
| 32 | Shan State | Chinshwehaw (Pachethaw Chaung) | Feb. 1992 | 7 | 300 | 100 x 1 VoestAlpine 200 x 1 Chinese | 8.9 | 4.3 | 13 miles north of Kunlong | B | Kokan Area (Special Region 1). Chinese machine has more down time. |

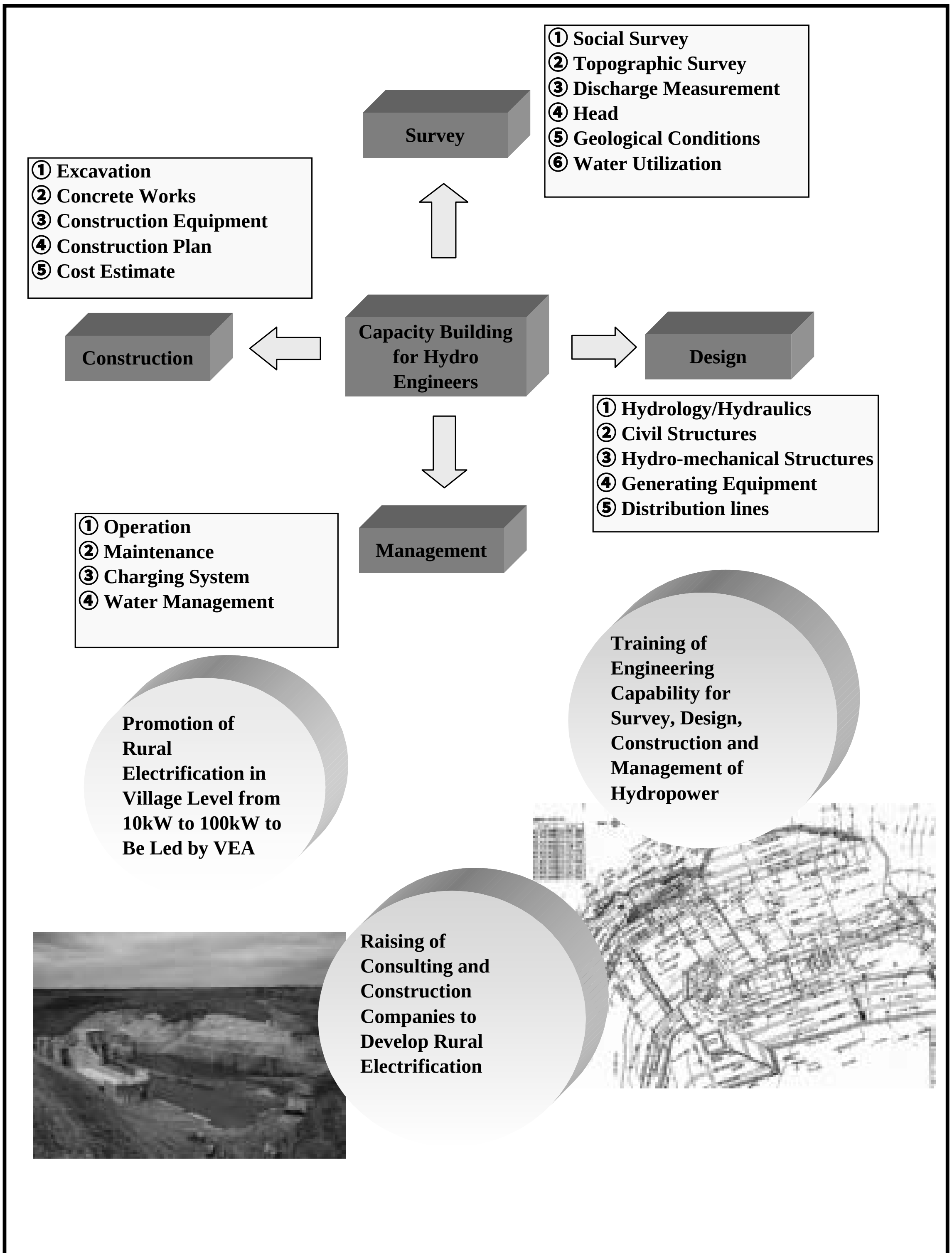
## List of Small and Mini-hydro Power Stations Existing and Under Construction in Myanmar (<10,000 kW) (3/3)

| No. | State/Division | Plant Name | Commissioned in | C. Area | $P_i$ | | $Q_d$ | $H_g$ | Location | Priority (A to C) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $km^2$ | kW | Unit | $m^3/s$ | m | | | |
| 33 | Shan State | Maing Lar | March 1992 | 32 | 60 | 30 x 2 | 0.3 | 19.8 | 56 miles from Kyaington | | Kokan Area (Special Region 1). Not in operation any more, needss confirmation. |
| 34 | Shan State | Selu (Nam Lat Chaung) | March 1992 | 12 | 24 | 12 x 2 | - | 20.1 | 7 miles east of Mongyang | | Not in operation any more. |
| 35 | Shan State | Kunlong (Nam Hsawn Chaung) | Jan. 1996 | 71 | 500 | 250 x 2 | 1.7 | 40.8 | 15 miles east of kunlong, 3 miles east of Hopan | B | Chinese machines. |
| 36 | Shan State | Pon Hsan (Namnga Chaung) | commissioned | - | 80 | | - | 79.9 | Southwest of Pan Hsan (Pan Hkam) | | not known. |
| 37 | Shan State | Kyukok (Nam Hkan Chaung) | under const. | 78 | 320 | | - | 59.7 | 4 miles from Kyukok, near the border with China. | B | Civil works completed. Penstock & machines are not installed. Needs rehabilitation. |
| 38 | Shan State | Kong Nyaung (1) | 1985 | 1,306 | 6,800 | | - | 45.7 | 24 miles from Lashio | C | Belongs to a Mine, not of MEPE. |
| 39 | Shan State | Tatkyi Falls | July 1987 | 1,293 | 1,200 | 600 x 2 | - | 9.0 | 7 miles east of Yat Sauk | C | Finish machines. Renovated for its gear problem. Design flood 250 $m^3/s$. |
| 40 | Shan State | Namyao (Kong Nyaung 2) | April 1994 | 1,357 | 4,000 | 2,000 x 2 | 17.0 | 32.0 | 14 miles southwest of Lashio | C | Chinese machines. |
| 41 | Shan State | Kyaington-1 (Nam Wap Chaung) | July 1994 | 26 | 3,000 | 1,000 x 3 | 1.1 | 338.0 | 10 miles south of Kyaington | C | Chinese machines. 2 units out of order |
| 42 | Shan State | Kyaukme (Nam Saung Ngau Chaung) | Sept. 1996 | 180 | 4,000 | 2,000 x 2 | 3.4 | 148.0 | 6 miles east of Kyaukme | B | Inspected on 9/2/2001. Sediment issue. Water shortage during the dry season. Design flood 200 $m^3/s$. |
| 43 | Shan State | Mepan | under const. | 16 | 2,000 | 1,500 only | - | 335.3 | 6 miles northeast of Mong Hsat | | YMEC machines. MEPE will now install machines. |
| Total | | | | | 72,441 | | | | | | |
| Total excluding those under construction | | | | | 40,121 | | | | | | |
| Total of only Priority A projects | | | | | 13,548 | | | | | | |
| | Shan State | Zawgyi I | July 1995 | 1,368 | 18,000 | 6,000 x 3 | 18.6 | 121.9 | 13 miles north of Yat Sauk | A | YMEC machines. 2 machines OK. Rotor of 1 unit needs replacement, turbine OK. |
| | Shan State | Zawgyi II | Oct. 1998 | 315 | 12,000 | 6,000 x 2 | 49.2 | Hmax 40.53 Hmin 23.78 | | | |

Note: The priority is judged on the basis of the machine damages and urgency of the rehabilitation works.

**Project Sheet CB-01: MOEP Capacity Building Project**

| 1. Sector/Sub-sector:<br>Energy/Rural Electrification | 2. Location:<br>Yangon or Mandalay |
|---|---|
| 3. Implementing Agencies:<br>Myanma Electric Power Enterprise (MOEP) | |
| 4. Objectives:<br>1. To establish MOEP Technology Center and train young engineers and technicians from MOEP, local governments, and NGOs who will be engaged in promotion and O&M of power supply and rural electrification in Myanmar. | |
| 5. Justification:<br>13. To meet the policy of the Government to implement 2,000 MW in the short-term and more in the long-term, capacity building of the staff for implementation and O&M of hydropower projects is essential together with rural electrification with hydro;<br>14. High quality works will contribute to the realization of a long lifetime of the hydro projects, which will result in the best interests of the Nation;<br>15. Past experience proves that OJT through participation in the actual construction works with guidance from experts, or in the manufacturing and repair works in the power stations and workshops are the most effective ways of training young engineers and technicians.<br>16. Penstock pipes, small gates and trashracks, transformers, concrete poles for distribution lines, etc. can be manufactured in Myanmar. However, there has been little experience and know-how on manufacturing and repairing turbines-generators. These technology and know-how are much needed in Myanmar. | |
| 6. Project Description:<br>2. To establish MOEP Technology Center with the following divisions:<br>● Laboratory and Field Investigation Division;<br>● Planning and Design Division;<br>● Construction Technology and Management Division; and<br>● Workshop for O&M of Electro-Mechanical Works.<br>3. The training will cover:<br>● Investigation stage: field reconnaissance, topo-survey, discharge measurement, geological investigations, material testing, environmental survey, and social survey;<br>● Planning and design stage: hydro-meteorology, demand forecasting, formulation of development plans, analyses and planning of Power Grid, basic and detailed design, technical specifications, construction planning and cost estimates, economic aspects, power tariff, environmental aspects, organization for O&M and management of electricity business;<br>● Implementation stage: Civil construction works including tunneling, hydro-mechanical works, electro-mechanical works, and distribution lines works; and<br>● O&M and monitoring stage: O&M of the generation and distribution facilities, meter reading, tariff collection, accounting, management of staff, vehicles, spare parts, and fund raised and accumulated, reporting to relevant agency. | |
| 7. Implementation Period:<br>2 years for establishment of the Center, to be followed by training activities | |
| 8. Estimated Benefit and Beneficiaries:<br>Trainees directly and customers of MEPE and rural electrification systems indirectly | |
| 9. Estimated Environmental Impacts:<br>No special changes anticipated. | 10. Estimated Costs:<br>US$ |




**CAPACITY BUILDING FOR RURAL ELECTRIFICATION**